"BY HAMMER AND HAND ALL THINGS DO STAND"

AUDELS MASONS AND BUILDERS GUIDE #4

A PRACTICAL ILLUSTRATED TRADE ASSISTANT ON

MODERN CONSTRUCTION

FOR BRICKLAYERS-STONE MASONS CEMENT WORKERS-PLASTERERS AND TILE SETTERS

EXPLAINING IN PRACTICAL, CONCISE LANGUAGE AND BY WELL DONE ILLUSTRATIONS, DIAGRAMS CHARTS, GRAPHS AND PICTURES, PRINCIPLES ADVANCES, SHORT CUTS-BASED ON MODERN PRACTICE-INCLUDING INSTRUCTIONS ON HOW TO FIGURE AND CALCULATE VARIOUS JOBS

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Foreword

"The Audel's Guides to the Building Trades" are a practical series of educators on the various branches of Modern Building Construction and are dedicated to Master Builders and their Associates.

These Guides are designed to give technical trade information in concise, accurate, plain language.

The Guides illustrate the hows and whys, short cuts, modern ways and methods of the foundation principles of the art.

Each book in the series is fully illustrated and indexed for readiest form of reference and study.

The Guides will speak for themselves—and help to increase the reader's knowledge and skill in the Building Trades.

—*Publishers.*

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CHAPTER 95

How to Read Blue Prints

In order to "read" a blue print, that is, to form a clear idea of the shape of the object which may be represented on the print by one or several "views" as may be necessary, it is necessary to first understand the various systems used in drawing. There are two general classes of drawings which may be designated as:

1. *Pictorial Drawings.*

a Cabinet projection
b Modified cabinet projection.
c Isometric projection
d Perspective

2. *Descriptive or working drawings.*

a Orthographic projection.

The first mentioned class or pictorial drawings picture the object as it actually appears, hence no difficulty is encountered.

Of the several methods used in pictorial drawings, the one known as ***perspective*** is the only one that gives an accurate picture of the object as the actual object would be seen by the eye, or reproduced by the camera.

Owing to the difficulty of making perspective drawings, several methods of approximating perspective have been devised as cabinet projection, isometric projection, etc., and for the uses to which they are put, answer the purpose just as well as a perspective drawing and result in considerable saving of time. Such drawings since they are intended to imitate perspective, may be classed as *fake perspective*.

It is with the second mentioned class that difficulty is experienced by the student in "reading" them since they do not show a picture of the object as it actually appears, but usually two or three "views" or separate drawings are necessary to completely define the object. Hence, the reader must examine each of these views and then mentally put them together to form an idea of the shape of the object.

The pictorial drawings are taken up first, because with the

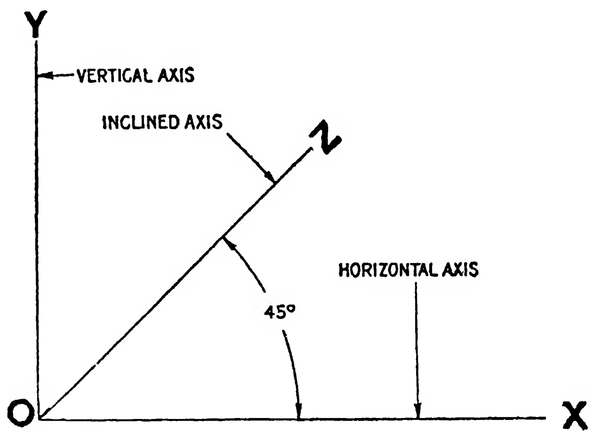


FIG 5,281 —Cabinet projection axes

exception of perspective they are more easily understood and lead up to the second class of working drawings.

1. Pictorial Drawings

Cabinet Projection.—In this system of drawing, the lines of an object are drawn parallel to three axes, one of which is horizontal, a second vertical, and the third, inclined 45° to the

horizontal, as in fig. 5,284. The vertical and horizontal axes lie in the plane of the paper, and the vertical and inclined axes lie in a plane intended to appear to the eye as being at right angles to the plane of the paper.

These axes lie in planes at right angles to each other and are known as the horizontal, vertical and profile planes.

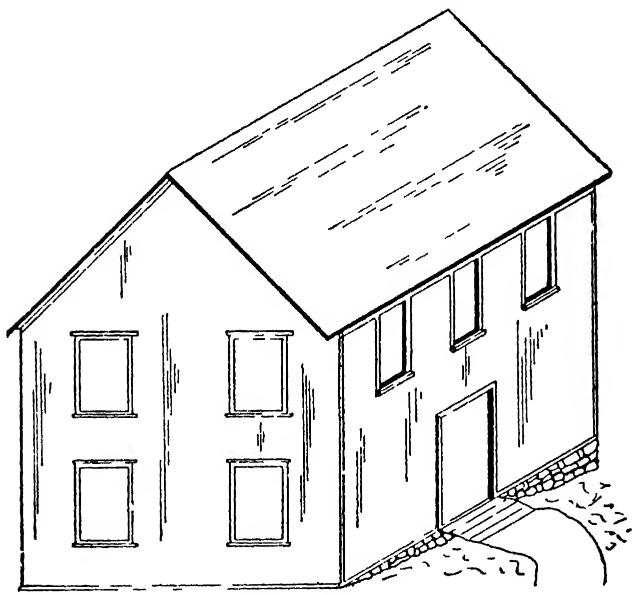


FIG. 5,285 — Cabinet projection of barn with one axis of 40° inclined to the right.

In cabinet projection it is to be remembered that:

1. All horizontal measurements, parallel to the length of the object must be laid off parallel to the horizontal axis, in their actual sizes.

2. All vertical measurements, parallel to the height of the object, must be drawn parallel to the vertical axis in their actual sizes.

3. All measurements parallel to the thickness of the object must be laid off on lines parallel to the 45° axis, in sizes of only one-half of the actual corresponding measurements.

It is not essential which side of the object should be considered as its length and which side, its thickness.

Problem 1.—To draw a cube in cabinet projection.

First draw the three axes, OX, OY, OZ, as in fig 5,286 Lay off OA and OC, on OX and OY, equal to side of the given cube, and complete the side by drawing CB and AB On OZ, lay off OG, equal to ½ OA Through

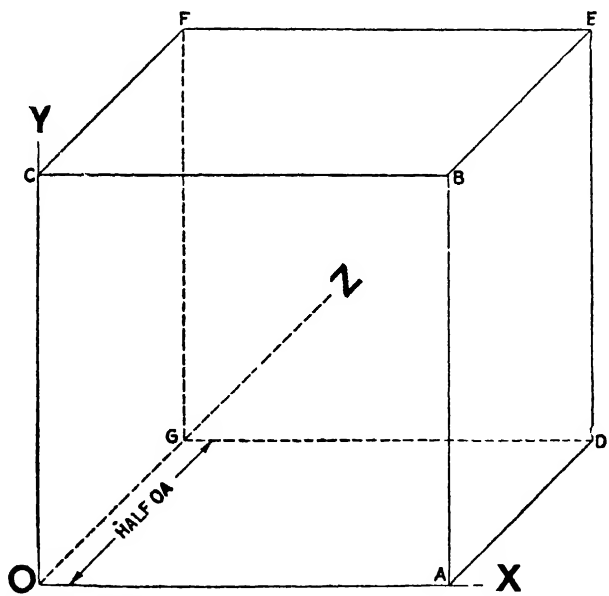


Fig 5,286 —Cabinet projection of a cube.

C, draw a line parallel to OZ, and through G, a dotted line parallel to OY, giving the lines CF and GF Similarly through points G F,A and B, draw parallels to the axes, thus completing the cube

In the drawing, the face ABCO, is regarded as lying in the plane of the paper, the face DEFG, as parallel and the other faces ABED and OCFG, as perpendicular to the plane of the paper. The edges which would be

invisible if the cube were made of opaque material such as wood, are represented by dotted lines.

Problem 2.—To draw a right cylinder with its bases in the XOY plane; length of cylinder 3 times the diameter.

This is the best position to draw a cylinder because the bases will be circles and the difficulty of describing ellipses avoided.

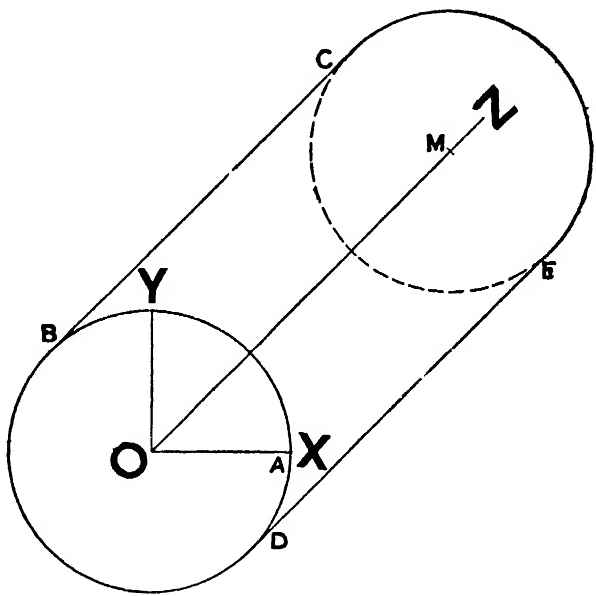


FIG. 5,287.—Cabinet projection of a cylinder with bases parallel to the plane of the paper.

Draw the axes as usual. With O, as center and OA, equal to radius of cylinder, describe a circle. On OZ, lay off OM = 3 times OA (since length of cylinder = 3 times the diameter.)

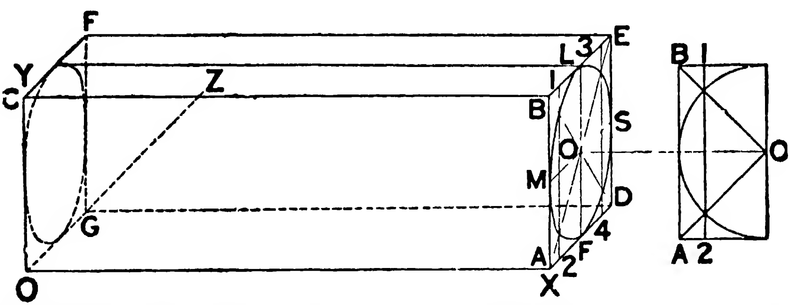
With same radius describe a circle through M, and draw tangents BC, and DE, thus completing the outline of the cylinder

The portion of the circle about M, between C and E, is shown by dotted

lines because it would be invisible if the cylinder were made of opaque material.

Problem 3.—To draw a prism enclosing a cylinder with its bases parallel to the YOZ plane; length of cylinder 3 times the diameter.

Draw in the cube as directed in Problem 1, making AD = $^1/_6$ OA, as in fig. 5,288. Now, show half of the base ABED, in the plane of the paper as in fig. 5,289. Here, draw diagonals OB and OA, and describe the half circle tangent to the sides. Through the intersection of the circle with diagonals draw line 12.



FIGS. 5,288 and 5,289.—Cabinet projection of a prism enclosing a right cylinder with its bases parallel to the YOZ plane.

In fig. 5,288 make B1 = ½ of B1 in fig. 5,289 and draw line 12, in fig. 5,288, and by similar construction line 34. Next draw diagonals AE and BD. The intersection of lines 12 and 34 with these diagonals will give four points together with points MLSF, through which to construct an ellipse representing the base of the cylinder as seen in profile constructing a similar ellipse at the other end and drawing the two tangents to the ellipses completes the outline of the cylinder.

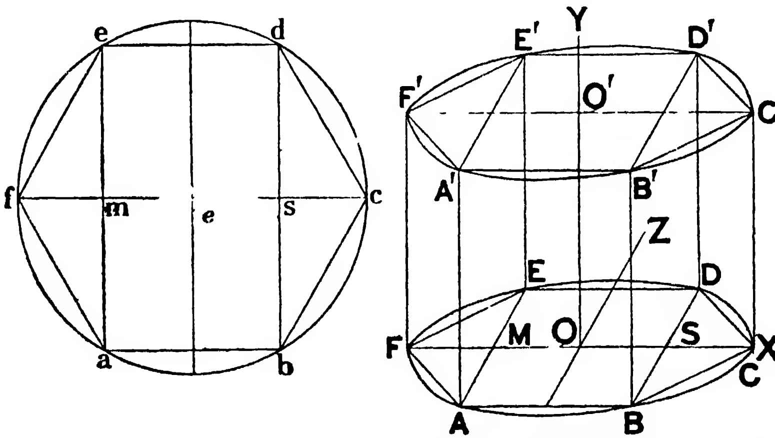
Problem 4.—To draw a hexagonal prism inscribed in a right cylinder whose base equals twice diameter.

In construction fig. 5,290, describe a circle of diameter equal

to diameter of the cylinder. Inscribe a hexagon. In fig. 5,291 lay off OF and OC, equal to *of* and *oc*.

Transfer points *m,s*, obtaining M,S, and through M and S, draw lines parallel to OZ, and on these lines lay off ME = ½ *me;* MA = ½ *ma*, etc. Through the points thus obtained draw in the ellipse ABCDEF.

Similarly construct upper ellipse A′B′C′D′E′F′, at elevation OO′ = ¾ FC, and draw tangents thus completing the cylinder.



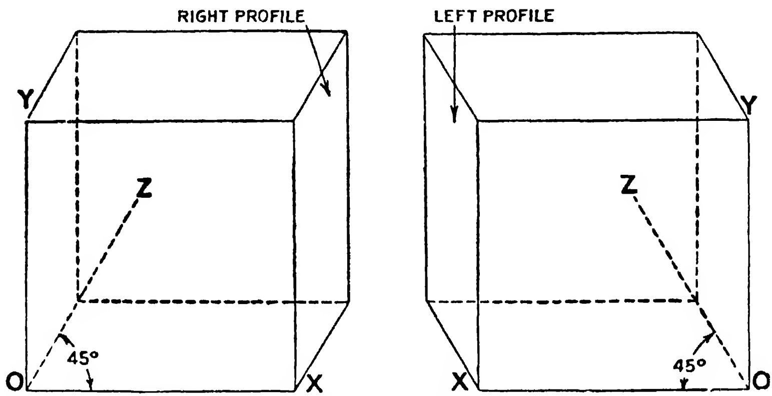
FIGS. 5,290 and 5,291.—Cabinet projection of a hexagonal prism inscribed in a right cylinder.

Join AB, A′B′, BC, B′C′, etc., and AA′, BB′, etc., thus completing outline of inscribed hexagonal prism.

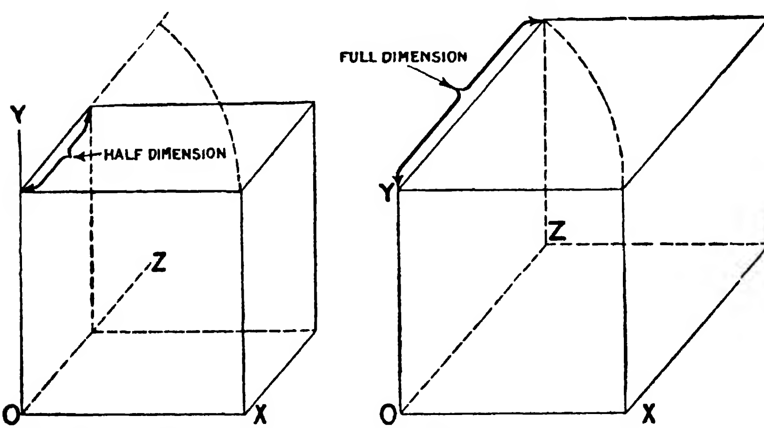
Modified Cabinet Projection.—There are various ways in which the 45° one-half foreshortened profile cabinet projection just described can be modified for convenience to suit special conditions. For instance, instead of inclining the OZ, axis to the right, as in fig. 5,292, it may be pointed to the left as in fig. 5,293.

Instead of foreshortening the profile dimension one half, as in fig. 5,294, in some cases, where dimensions are to be taken from the drawing, the profile may be made full dimension as in fig. 5,295.

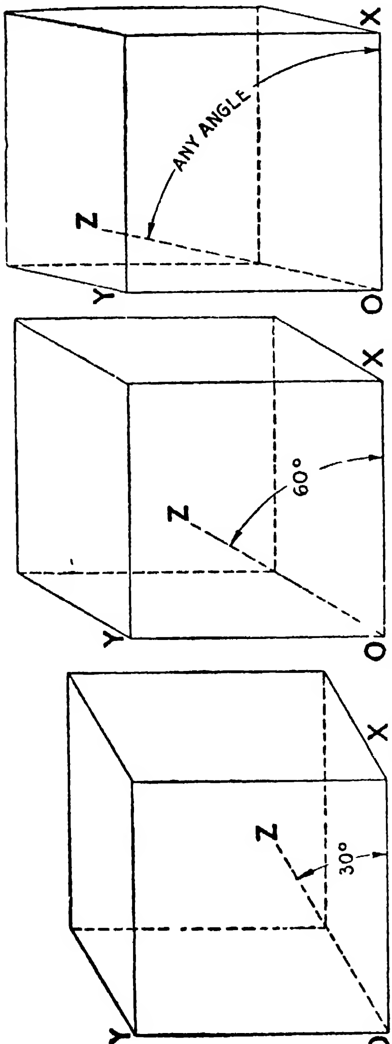
Sometimes, because of the limited space available, it is desirable to take



FIGS. 5,292 and 5,293.—45° cabinet projection with right and left profile.



FIGS. 5,294 and 5,295.—Half and full profile dimension 45° cabinet projection. Evidently where all lines are drawn full dimension as in fig. 5,295, the drawing is made without calculating the profile dimensions, and especially in case of a complicated object time is saved



FIGS. 5,296 to 5,298.—Modified full profile dimension cabinet projection with OZ axis at 30° (fig. 5,296), 60° (fig. 5,297), and at any angle fig. 5,298). Evidently these modifications render the system flexible with respect to space and clear representation of any special part of an object.

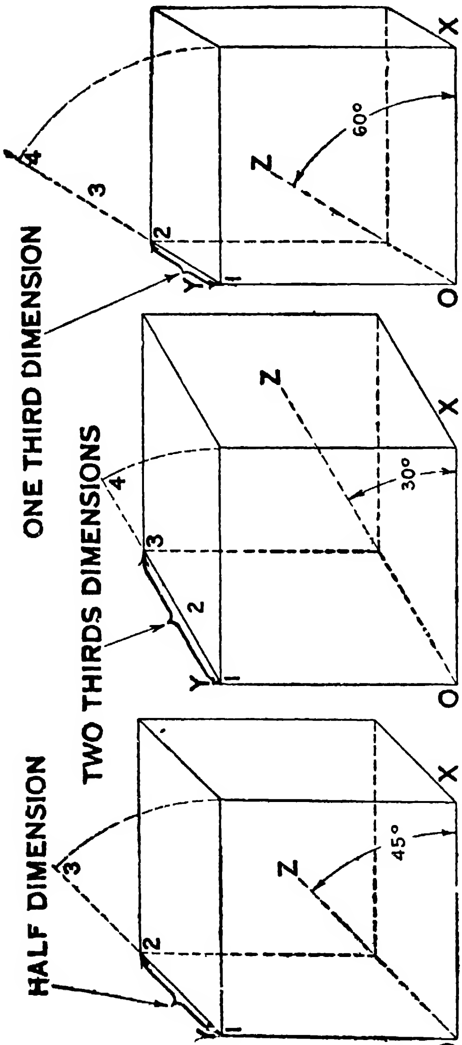
the OZ, axis at some angle other than 45°. In such cases it is usually taken at 30° or 60°, because these angles are obtained directly with the T square and triangles—the object of the projection system being to use these instruments to conveniently and quickly execute drawings. In special cases, obviously any angle may be taken to suit the conditions.

These modifications of cabinet projection are shown in figs. 5,296 to 5,301. The first three figures show the object in full profile dimension for comparison. However, to save space and approach the natural appearance of the object, the following are the approved proportions for the profile.

OZ axis 45°, profile half dimension.

OZ axis 30°, profile two-thirds dimension.

OZ axis 60°, profile one-third dimension.



FIGS 5,299 to 5,301 —Approved proportions for profile dimensions of 45°, 30° and 60° cabinet projection

The appearance of an object drawn to these proportions is shown in figs. 5,299 to 5,301.

Isometric Projection.—By definition the word *isometric* means *equal distances*, and as here applied, isometric projection is a system of drawing *with measurements on an equal scale in every one of three sets of lines* 120° *apart and representing the three planes of dimension.*

In other words, the axes are taken 120° apart and there is no profile foreshortening as in cabinet projection, all lines being drawn full length.

Isometric projection further differs from cabinet projection in that none of the three planes lie in the plane of the paper.

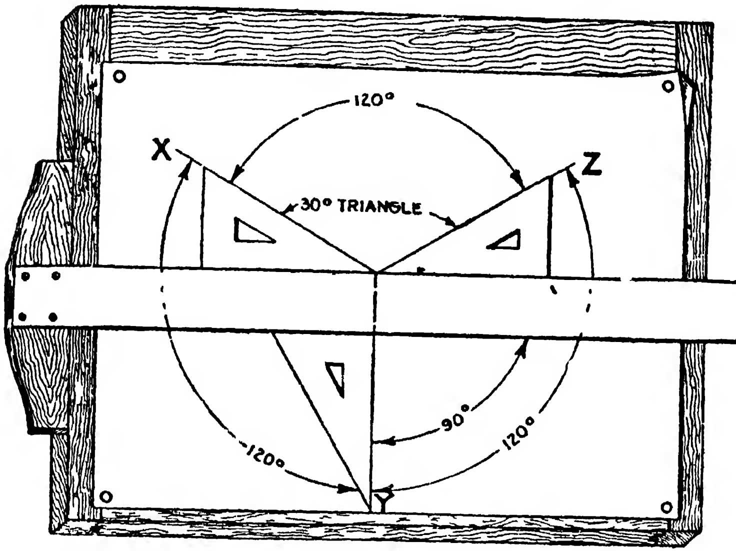
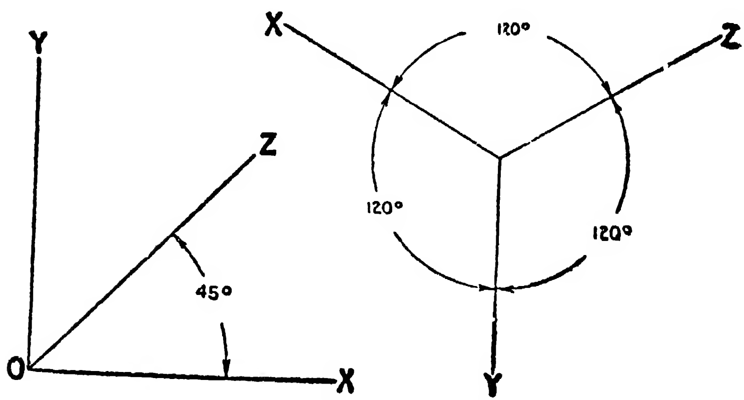


FIG. 5,302 —Isometric axes laid out at 120° to each other with 30° triangle and T square

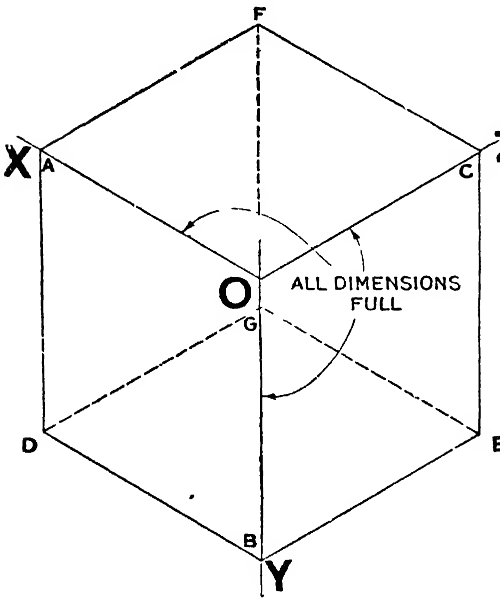


FIGS. 5,303 and 5,304 —Comparison of cabinet and isometric axes

Fig. 5,302 shows method of laying out the isometric axes using T square and 30° triangle. Figs. 5,303 and 5,304 show comparison of axes of the cabinet and isometric systems.

Problem 5.—To draw a prism in isometric projection.

First draw the axes OX, OY and OZ, at 120° as explained in fig 5,302.



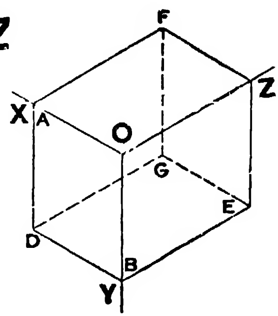


FIG. 5,305 —Isometric projection of a cube.

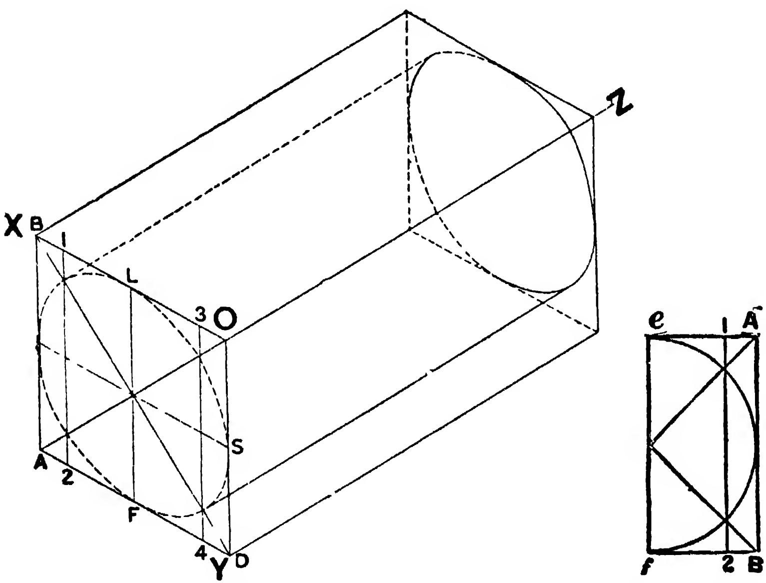
FIG. 5,306.—Isometric projection of a parallelopipedon showing completed dotted outline of invisible portion as compared with that of the cube fig 5,305 in which part of the dotted line FG, falls behind OB. The reference letters are the same in both figures.

From O, fig. 5,305, lay off on the axes just drawn OA = OB = OC = length of side of the cube. Through points A,B,C, thus obtained, draw lines parallel to the axes, giving points D,E,F, thus completing visible outline of the cube.

Through D, E and F, draw dotted lines intersecting at G, which gives

the invisible outlines of the cube, assuming it to be opaque. An objection to this view is that the point G, falls behind the line OB, thus the outline of the invisible portion does not appear so well defined as it would in the case of a parallelopipedon as in the little fig. 5,306 at the right.

An objection to isometric projection is that, since no projection plane lies in the plane of the paper, it is necessary to construct ellipses to represent circular portions of an object and this requires time and skill.

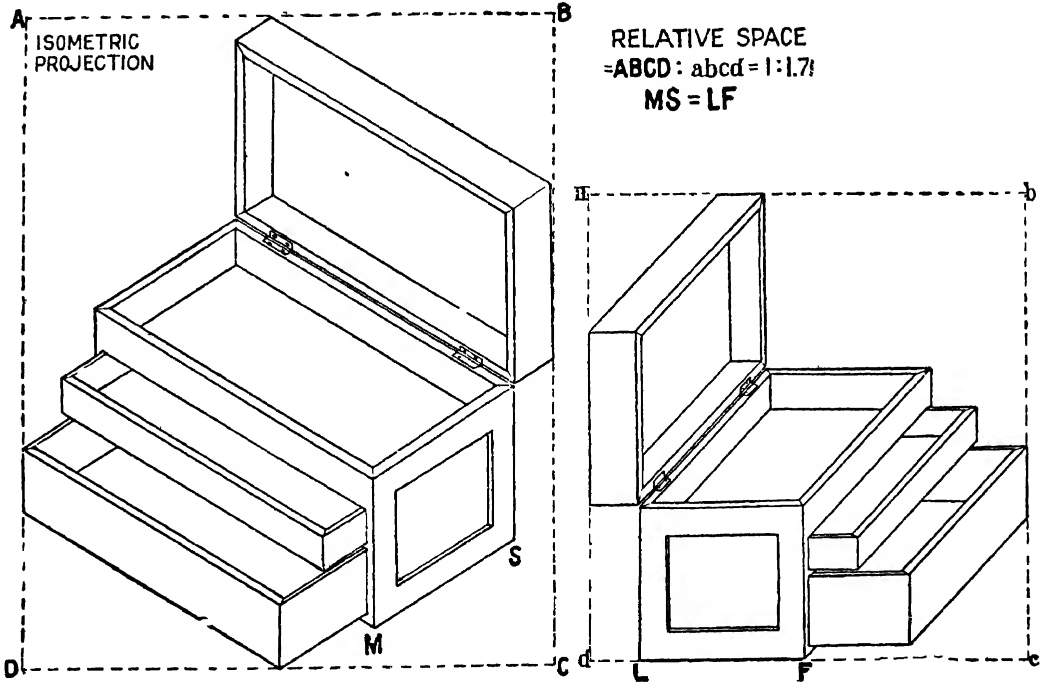


FIGS. 5,307 and 5,308.—Isometric projection of a horizontal prism with inscribed cylinder.

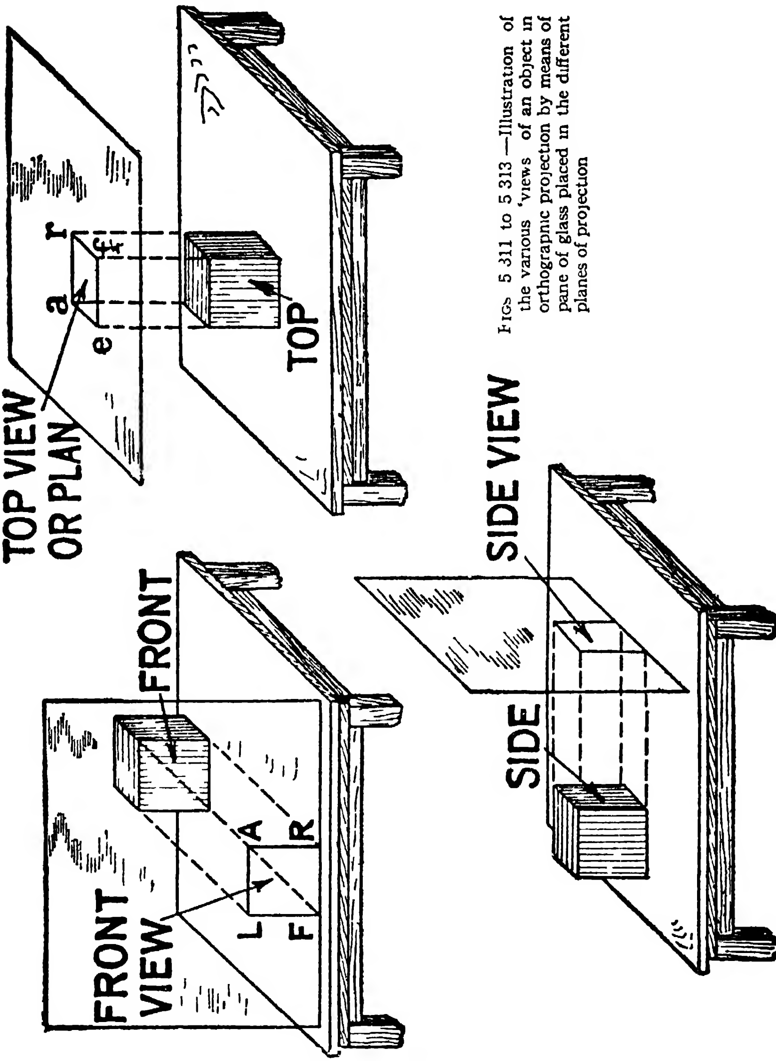
Problem 6.—Draw a horizontal prism with inscribed cylinder; length of cylinder two times the diameter.

Draw the prism as explained in fig. 5,305, and drawn in fig. 5,307, making its length twice its side. Now construct the half end view in plane of paper (fig. 5,308); describe circle, diagonals and intersecting line 12.

Transfer from fig. 5,308 line 12 to fig. 5,307 and draw symmetrical line



FIGS 5,309 and 5,310 —Comparison of isometric and cabinet projection showing relative space required to represent the same object drawn to same scale Note that dimension MS = LF The saving in space by cabinet projection is due to the position of the axes and the foreshortening of the profile dimensions



FIGS. 5,311 to 5,313.—Illustration of the various 'views' of an object in orthographic projection by means of pane of glass placed in the different planes of projection.

34 and diagonals. The intersections, together with points MS, and LF, of axial lines through the center, give eight points through which construct ellipse.

Construct also a similar ellipse at other end of prism and join two ellipses with tangents, thus completing outline of inscribed cylinder.

An objection to isometric projection is the greater amount of space required as compared with cabinet projection; this point is shown in figs. 5,309 and 5,310.

Orthographic Projection.—Isometric drawing and cabinet projection, while showing the object as it really appears to the eye of the observer, are neither of them very convenient methods to employ where it is necessary to measure every part of the drawing for the purpose of reproducing it.

Drawings suitable for this purpose, generally known as *working drawings*, are made by the method known as *orthographic projection*.

In cabinet or isometric projections, three sides of the object are shown in one view, while in a drawing made in orthographic projection, but one side of the object is shown in a single view.

To illustrate this, a clear pane of glass may be placed in front of the object intended to be represented.

In fig. 5,311 a cube is shown on a table; in front of it, parallel to one face (the front face) of the cube, the pane of glass is placed.

Now, when the observer looks directly at the front of an object from a considerable distance, he will see only one side, in this case only the front side of the cube.

The rays of light falling upon the cube are reflected into the eyes of the observer, and in this manner he sees the cube. The pane of glass, evidently, is placed so that the rays of light from the object will pass through the glass in straight lines, to the eye of the observer. The front side of the object, by its outline, may be traced upon the glass, and in this manner a figure drawn on it (in this case a square) which is the view of the object as seen from the front which in this case is called the *front elevation*.

One view, however, is not sufficient to show the real form of a solid figure. In a single view two dimensions only can be shown, length and height; hence the thickness of an object will have to be shown by still another view of it, as the top view or *plan*.

Now, place the pane in a horizontal position above the cube which is resting on the table, as in fig. 5,312, and looking at it from above, directly over the top face of the cube, trace its outline upon the pane; as a result, a square figure is drawn upon the glass, which corresponds to the apperance of the cube, as seen from above. This square on the glass is the top view of the cube, or its *plan*.

Fig 5,313 shows the manner in which a side view of the cube may be traced, the glass is placed on the side of the cube, which rests on the table as before, and the outline of the cube on the glass in this position, is called its *side elevation*.

Usually either two of the above mentioned views will suffice to show all dimensions and forms of the object, but to completely represent complicated objects, three or four views may be required.

In complicated pieces of machinery, however, additional views, three and even more, may be required to adequately represent the proportions and form of the different parts.

A drawing which represents the object as seen by an observer looking at it from the right side is called *the right side elevation* and a drawing showing the object as it appears to the observer looking at it from the left side is called *the left side elevation*.

In the case of a long object, a view at the end is called an *end view*.

A view of the object as seen from the rear is called the rear view or rear elevation, and a view from the bottom, the bottom view.

The different views of an object are always arranged on the drawing in a certain fixed and generally adopted manner, as described below.

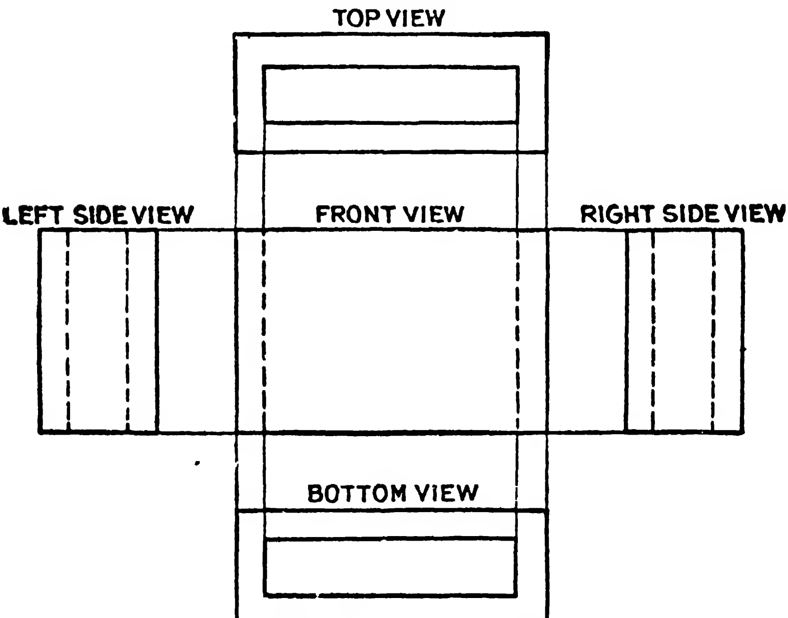
The front view is placed in the center; the right side view is placed to the right of the front view, and the left side view to the left; the top view is placed above the front view and the bottom view below it. The different views are placed directly opposite each other and are joined by dotted lines called *projection lines*.

By the aid of projection lines, leading from one view to the other, as in figs. 5,314 to 5,318, measurements of one kind may be transmitted from one view to the other; for instance, the height of different parts of an object may be transmitted from the front view to either one of the side views; in

like manner the length of different parts of the object may be transmitted by the aid of projection lines, to the bottom view and top view.

It is often desirable to show lines belonging to an object, although they may not be directly visible. In figs. 5,314 to 5,318 the top view and the bottom view show plainly that the object is hollow; looking at the object from the front or from the sides, however, the observer could not see the inside edges of the object, except it were made of some transparent material.

In projection drawing it is assumed for convenience that all objects are

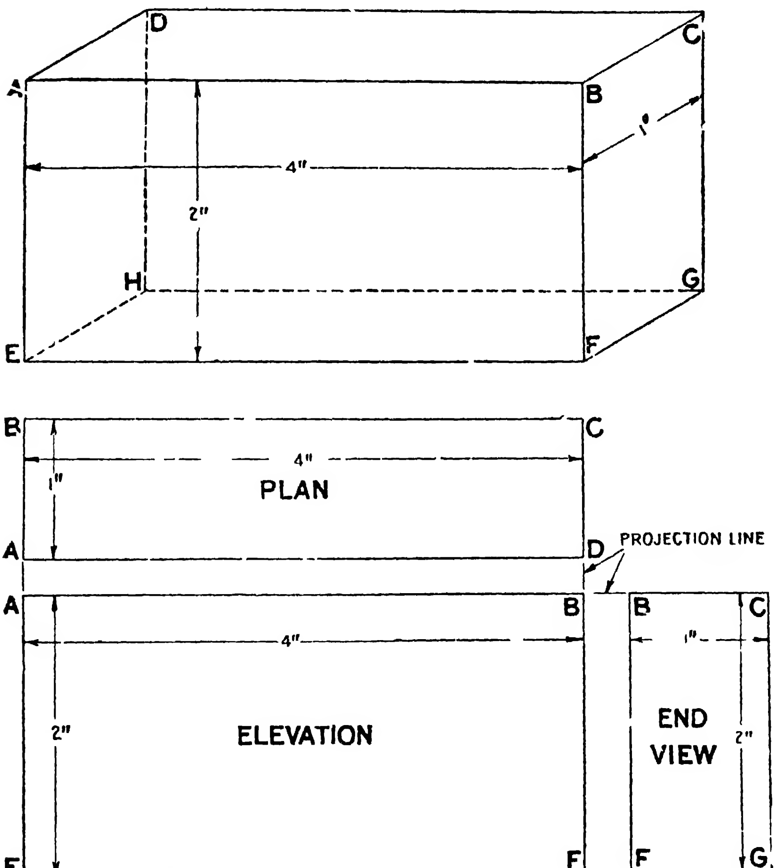


Figs. 5,314 to 5,318.—Five views of an object as drawn in orthographic projection.

made of such material, transparent enough to show all hidden lines, no matter from which side the object is observed; these hidden lines are represented in the drawing by dotted lines.

Problem 7.—Draw a plan, elevation and end view of the prism shown in fig. 5,319.

First draw the top view or plan as in fig 5,320, by drawing the rectangle ABCD, to scale making AB, = 1 in. and AD, 4 ins. For the elevation, project the point AB, down to the parallel line obtaining line AB

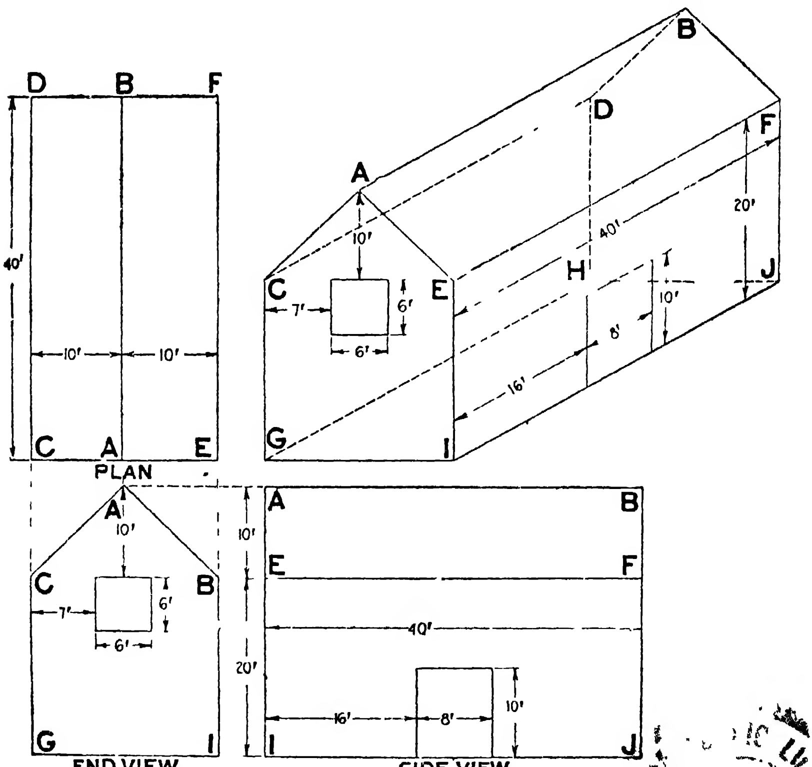


Figs 5,319 to 5,322 —Cabinet projection of a prism, and orthographic views of same, being shown in plan, elevation and end view

Lay off AE = 2 ins. and complete rectangle giving ABFE, or elevation. The end view BCGF, is drawn in a similar manner, side BF, being obtained by projection, and BC, by measurement.

Problem 8.—Draw plan, end and front views of the barn shown in fig. 5,324.

The plan will consist simply of a rectangle CDFE (fig. 5,323), the length



FIGS. 5,323 to 5,326 —Cabinet projection outline drawing of a barn and same drawn in orthographic projection.

of whose sides being obtained from the dimensions in the orthographic projections. The end view is projected down from points C,A,E, of the plan being identical with the end in fig. 5,324, because it is here drawn in the "OX, plane" which is the plane of the paper and accordingly is seen in true size.

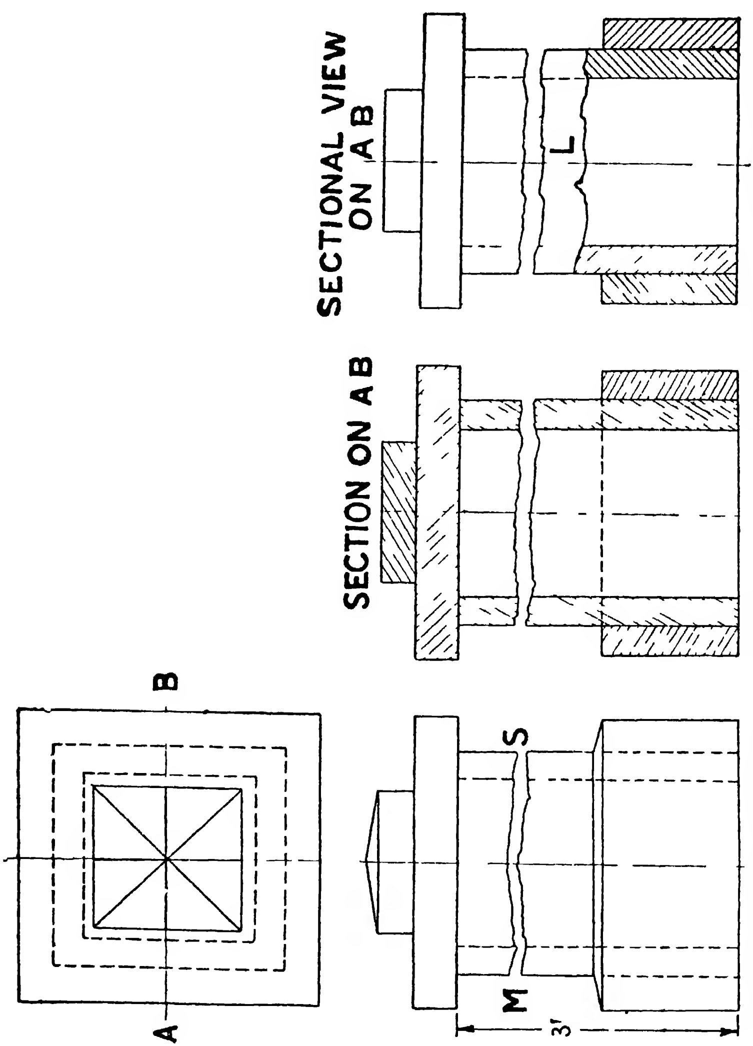
Similarly for the front view, project over the points A,B,I, of the end view and lay off AB, EF, and IJ, equal to 40 ft., the elevation of these lines being obtained from the given dimensions. The door is laid out in a similar manner.

Center Lines.—Objects which are symmetrical with respect to some axis drawn through the center are most easily drawn by first drawing such axis or *center line* and then drawing the object so that its center coincides with the center line. It is usual to make such lines broken by dot and dash, to distinguish them from the lines of the object. The author, however, prefers to draw solid center lines, obtaining the proper contrast to avoid confusion by drawing them much finer than those of the object, the same method being used also for dimension lines.

Figs. 5,327 and 5,328 show a rectangular built-up post drawn with center lines. Evidently since the figure is symmetrical with respect to these lines, equidistances are conveniently spaced off each side by aid of dividers and the drawing made quickly and with precision.

Since to show the entire length of the post would require considerable space, it is usual to "break it off" as at MS, by two ragged free hand lines, which indicate that part of its length is not shown. The construction of the post may be more clearly shown by drawing it as though it were sawed through from end to end along the line AB; thus showing only the half back of AB; it would then have the appearance as shown in fig. 5,329, called a *section* on AB. The surface assumed to be sawed is "section lined." That is, covered with a series of parallel lines usually inclined 45°, 30° or 60°. It will be noted that the section lines in one plank run in a different direction from those in an adjacent plank so as to distinguish the separate parts.

To draw section lines consumes time, hence, time may be saved by showing in section not more than is sufficient for clearness, the rest of the drawing being seen "in full" as in fig. 5,330; this is called a sectional view. Here the



FIGS 5 327 to 5 336.—Orthographic projection drawing of a built up post illustrating center lines, section, and sectional view also the method of reducing space required for drawing of a long object by "breaking it off" as at MS.

post is shown in full down to the ragged line L, below this line the post is considered as being cut away to the axis AB.

Dimensions on Drawings.—When the draughtsman has properly executed his work every dimension necessary for building the object illustrated will be found on the blue print *so that no measurements* need *be taken by the workman.* All measurements are usually given *with reference to center lines.* The inch marks are often and properly omitted. The foot and inch marks (′ ″) being used only when the dimension is ex-

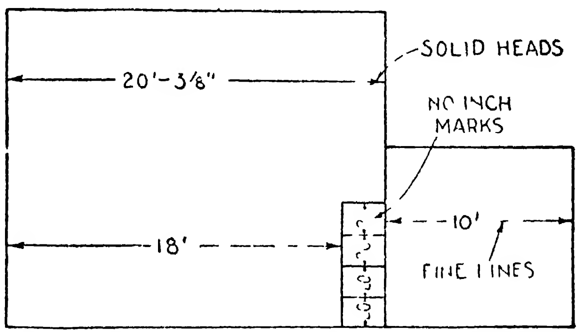


FIG 5,331 -Method of dimensioning drawing as preferred by the author Note, solid arrow heads that can be seen, fine dimension lines which by contrast are not confused with the lines of the drawing, no inch marks where dimension is in inches only

pressed in feet and inches. A good draughtsman anticipates the measurements which will be looked for by the workman in doing the work and puts these dimensions on the drawing.

The author objects to the usual style of dotted dimensions and center lines and weak arrow heads, and prefers to make these lines and arrow heads solid, the lines being drawn very fine to distinguish them from the object as shown in fig. 5,331.

The dimensions written on the drawing should always give the actual finished sizes of the object, no matter to what scale the object may be drawn.

All dimensions which a shopman may require should be put on a drawing, so that no calculation be required on his part.

For instance, it is not enough to give the lengths of the different parts of the object, but the length over all, which is the sum of all these lengths, placed outside and the figures also be put outside, in which case an arrow should be put in to indicate the proper position of the figures.

The figure should be placed in the middle of the dimension line at right angles to that line, and so as to read either from the bottom, or from the right hand side of the drawing. The arrow heads should be put inside of the lines, from which the distance, as given in the dimension, is reckoned.

The dimension lines should also be put in the drawing, very near to the spaces or lines, to which they refer.

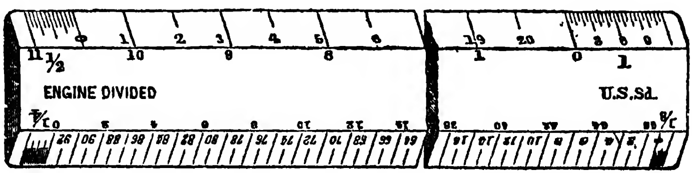


FIG. 5,332 —Flat draughtsman's box wood scales. *An explanation* of the 1 in. and ½ in. scales will suffice for all. Where it is used as a scale of 1″ to one foot, each large space, as from 0 to 12 or 0 to 1, represents a foot, and is a foot at that scale. There being 12″ in one foot, the twelve long divisions at the left represent inches; each inch is divided into two equal parts, so from 0 to one division at the left of 9 is 9½″ and so on. The 1″ and ½″ scales being at opposite ends of the same edge, it is obvious that one foot on the 1″ scale is equal to two feet on the ½″ scale, and conversely, one foot on the ½″ scale is equal to six inches on the 1″ scale; and 1″ being equal to one foot, the total feet in length of scale will be 12; at ½″ to 1 foot the total feet will be 24.

When "the view" is complicated, dimension lines drawn within it, might tend to make it still more obscure and difficult to understand; in such a case the dimension lines should be carried outside of the view and extension lines drawn from the arrow heads to the points, between which the dimension is given.

When the dimension includes a fraction, the numerator should be separated from the denominator preferably by a horizontal line instead of by an inclined line; care should be taken to write the figures in a very clear and legible manner and crowding should be avoided.

Drawing to Scale.—The meaning of this is, that the drawing

when done bears a definite proportion to the full size of the particular part, or, in other words, is precisely the same as it would appear if viewed through a diminishing glass.

When it is required to make a drawing to a reduced scale, that is, of a smaller size than the actual size of the object, say, for instance, ½ full size, every dimension of the object in the drawing must be one-half the actual size; in this case one inch on the object would be represented by ½ inch. Such a reduced drawing could be made with an ordinary rule. This, however, would require every size of the object to be divided by the proportion of the scale, which would entail a very great loss of time in calculations. This can be avoided by simply dividing the rule itself by 2, from the beginning. Such a rule or *scale* as it is generally called, will be divided in ½ inches, each half inch representing one full inch divided into ½, ¼, ⅛, $^1/_{16}$, each of these representing the same proportions of the actual sizes of the object to be drawn. From this contracted scale the dimensions and measurements are laid off on the drawing.

A quarter size scale is made by taking three inches to represent one foot. Each of the three inches will be divided into 12 parts representing inches, each one of these again will be divided in ½, ⅛, $^1/_{16}$, etc.; each one of these representing to a quarter size scale the actual sizes of ½, ¼, ⅛, $^1/_{16}$ of an inch.

It must be mentioned that in several instances, in this work, distances in one figure are said to be equal to corresponding distances in the same object in another view, while by actual measurement they are somewhat different; this is owing to the use of different scales—each scale separate should be marked on the drawing.

It must be understood that the scale on a drawing is not given for a shopman to take his dimensions from: such dimensions must all be taken from the dimension figures; the scale is given for the chief draughtsman's use, or whoever may check the drawing, and also for the use of other draughtsmen who may

make at some future time alterations or additions to the drawing.

"Plans."—The ridiculous term "plans" as applied to a set of drawings, especially architectural drawings, has become so firmly established that it must be tolerated although it is an erroneous use of the term. A plan is a plan, and a set of drawings or blue prints showing for instance the construction of a

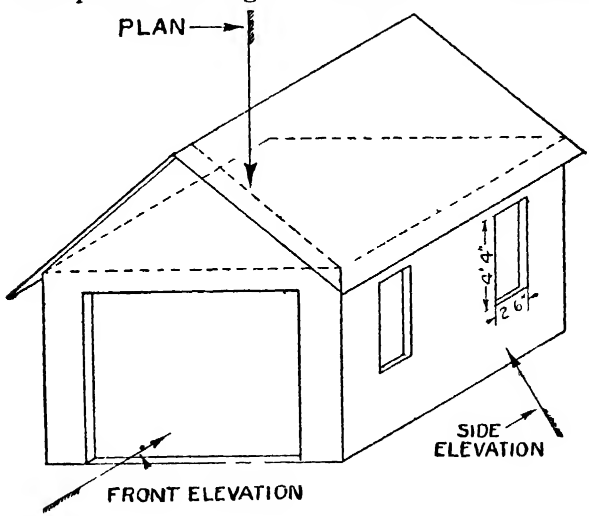


Fig. 5,333 —Cabinet projection of small garage, with arrow showing direction of sight for plan and elevations

house will consist of one or more *plans* and one or more *elevations*, and the difference should be clearly understood as has already been explained.

A plan is an *orthographic projection of the horizontal parts of* ***an*** *object, as distinguished from an elevation.*

An elevation is *the orthographic projection of the* ***vertical*** *parts of an object as distinguished from a plan.*

From the foregoing definitions the ridiculousness of calling a set of drawings "plan" must be apparent

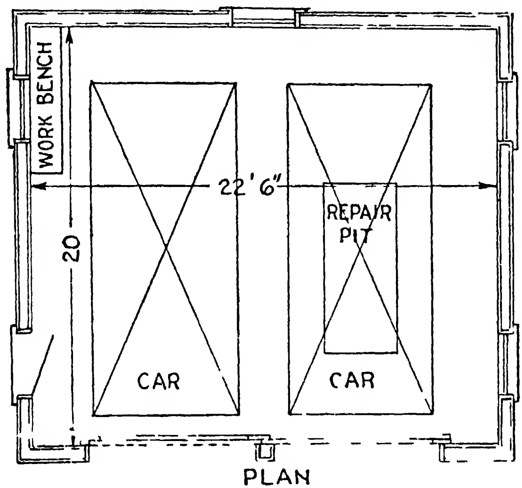


FIG 5,334 — Plan of small garage.

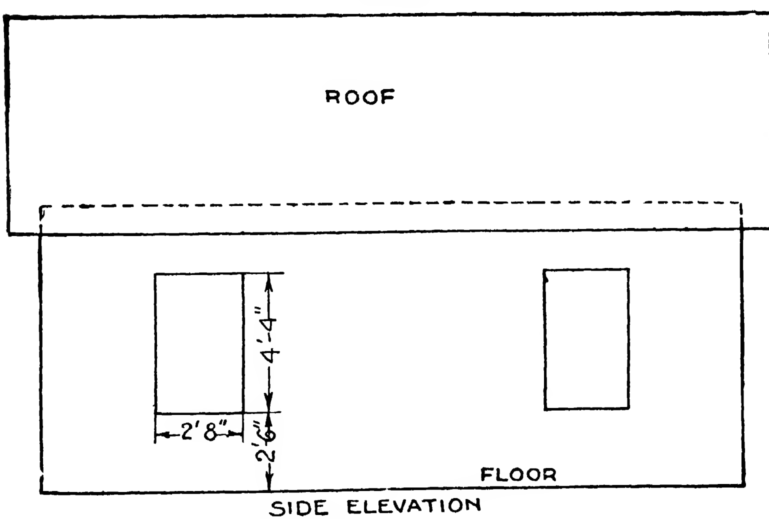


FIG 5,335 —Side elevation of small garage

The accompanying drawings of a small garage, figs. 5,333 to 5,336 will illustrate the distinction between plan and elevation. It will be noted that several elevations may be necessary to denote which side of the building is shown, these being called front elevation, side elevation, etc. Evidently both the plan and elevations are necessary to fully show the building. Thus while the plan gives the dimensions of the floor or outside horizontal dimensions and positions of the door and windows, it is necessary to consult the elevations to determine the height of the building, pitch of roof, etc.

An architect's preliminary free hand sketch of a plan for a house will appear as in fig. 5,337. Here, just the size of the various rooms are stated without any dimension lines to confuse his client. However, if the design be accepted he will work up a working drawing as shown in fig. 5,337 from which

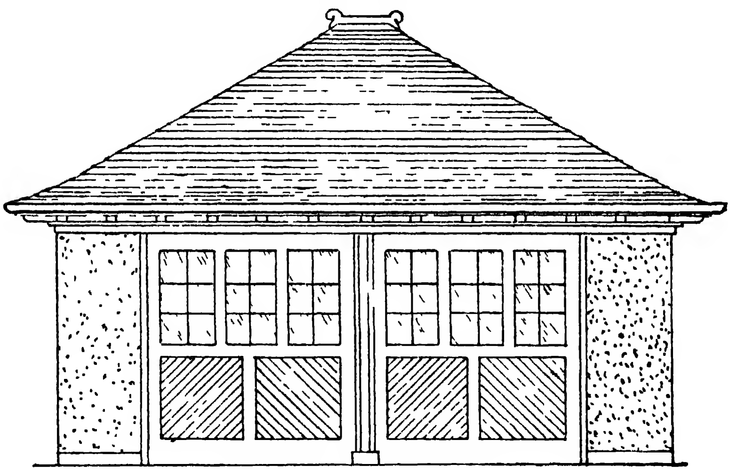


FIG. 5,336.—Front elevation of small garage.

a blue print is made. When the contractor and carpenter receives this (together with the necessary elevation to complete the set of so called "plans") they can obtain from them an exact idea of the building, and as all the dimensions are given an accurate estimate of the cost can be made and the structure built. Comparing figs. 5,337 and 5,338, it will be seen that each serves the purpose for which it is intended. In fig. 5,338, the client gets a better view of the outline of the building than would be the case were it obscured by a multiplicity of dimensions as in fig. 5,337.

On the other hand the carpenter having all the dimensions as in fig.

5,338 can cut up the lumber to the proper sizes and erect the building, whereas if he had to depend on fig. 5,337 he would have to do a lot of figuring to get sizes.

Conventional Representation on Architect's Drawings.—

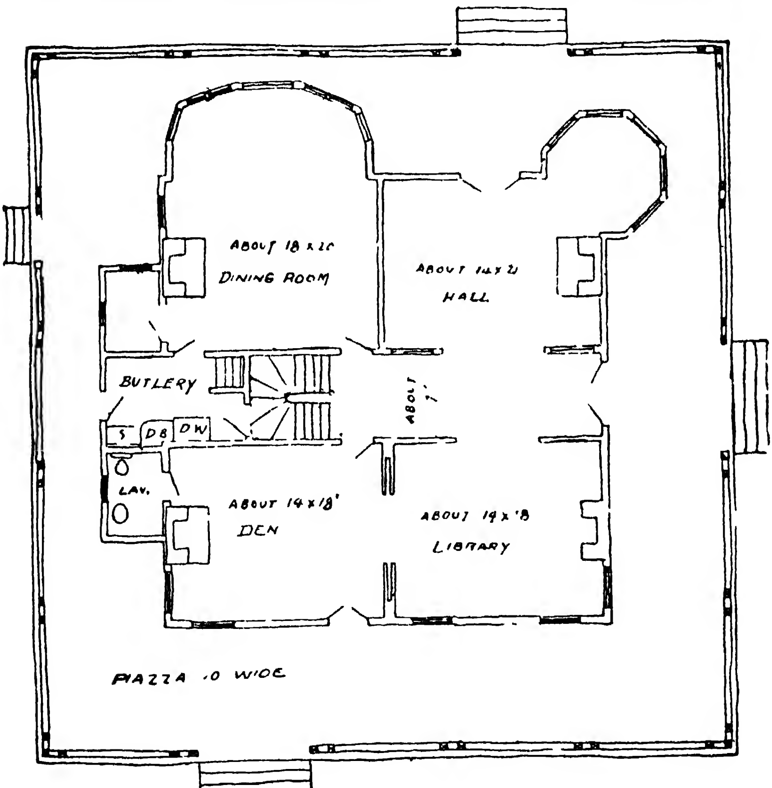


FIG. 5,337.—Architect's preliminary free hand sketch conforming to owner's ideas indicated in fig. 1,648. ***First floor plan.***

Every architect generally adopts his own method of indicating requirements on his plans, however there must be a general

sameness of many characteristics such as when locating electric light and bell wire outlets for which there is a standardized code. Outlets for plumbing fixtures are always indicated as given by the manufacturers.

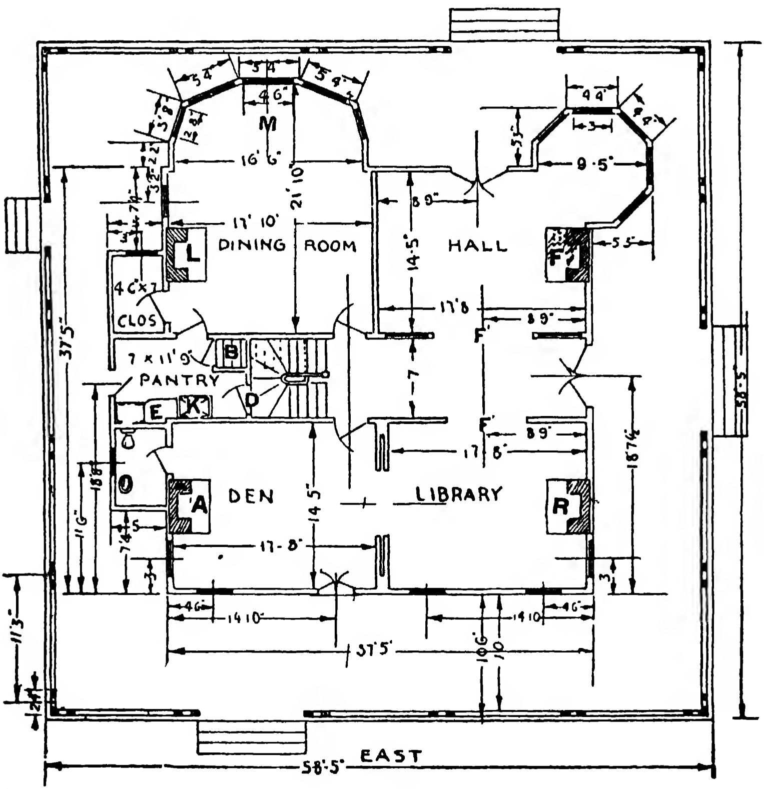
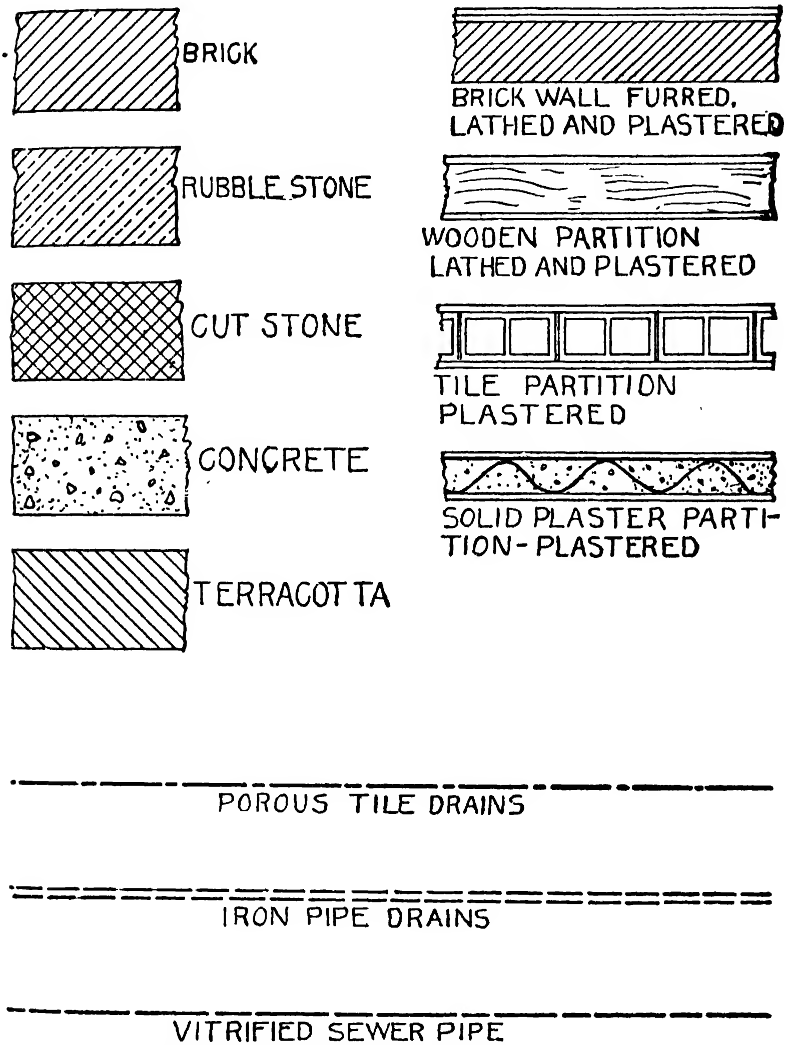
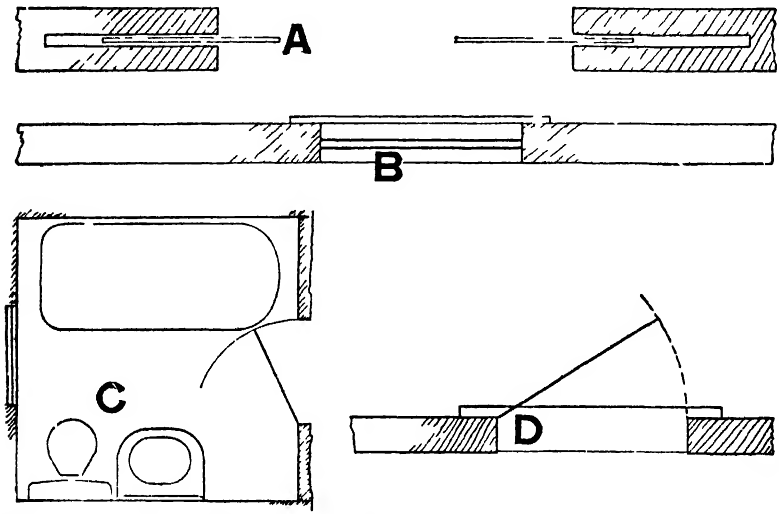


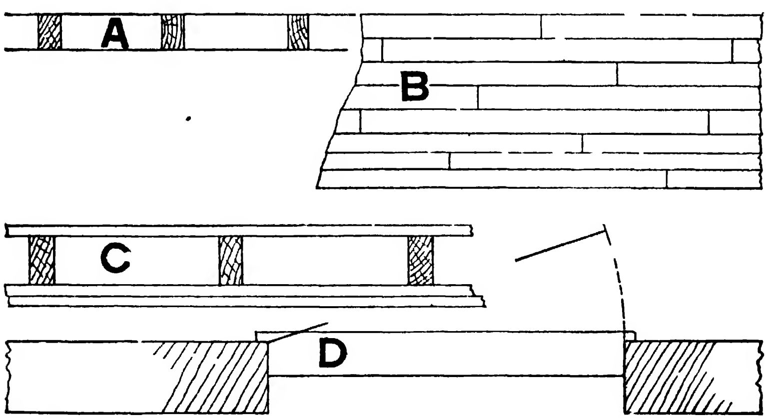
FIG. 5,338 —Development of plan of first floor. 3. The drawing shown in fig. 5,337, is completed by sketching in all the details, of windows, doors, showing the way they swing, etc., and putting in all the dimensions necessary for the builder, indication of materials, etc., the drawing after this is done, having the appearance as here shown. K, dumb waiter; B, cellar stairs L,ARF, fire places; D, pantry to hall, EE, sink and drain board; F, portier openings; G. sliding doors: H, lavatory.



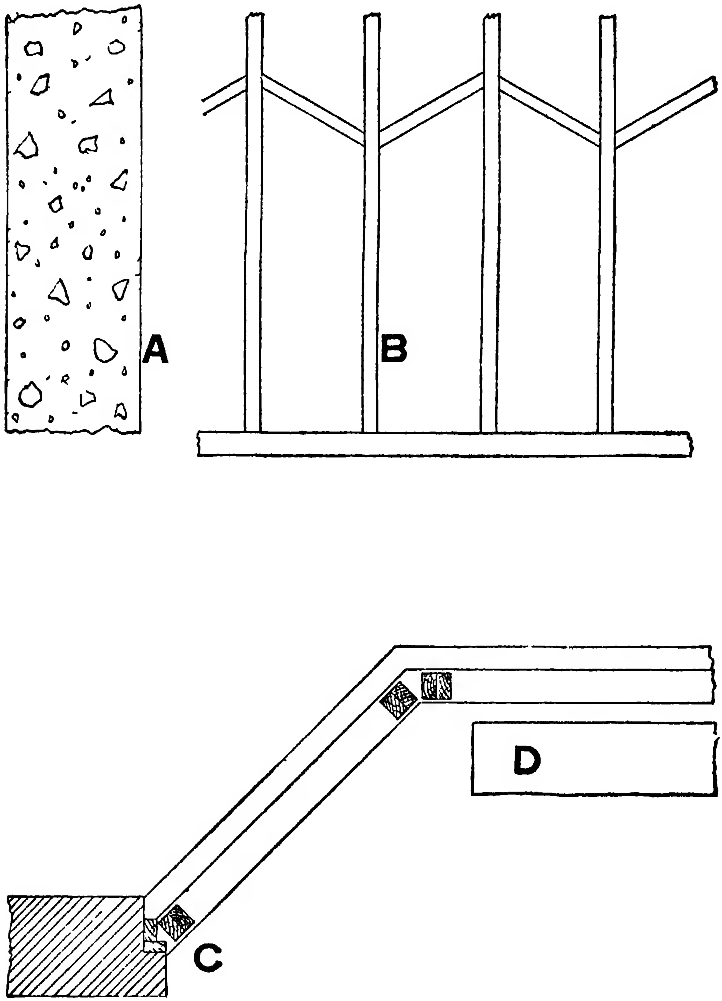
FIGS. 5,339 to 5,350.—Conventional symbols for representing materials on architectural drawing



Figs 5,351 to 5,354 —Conventional symbols for representing details on architectural drawings A, Sliding doors 1. B, Double hung sash C, Bath room D, Door sill

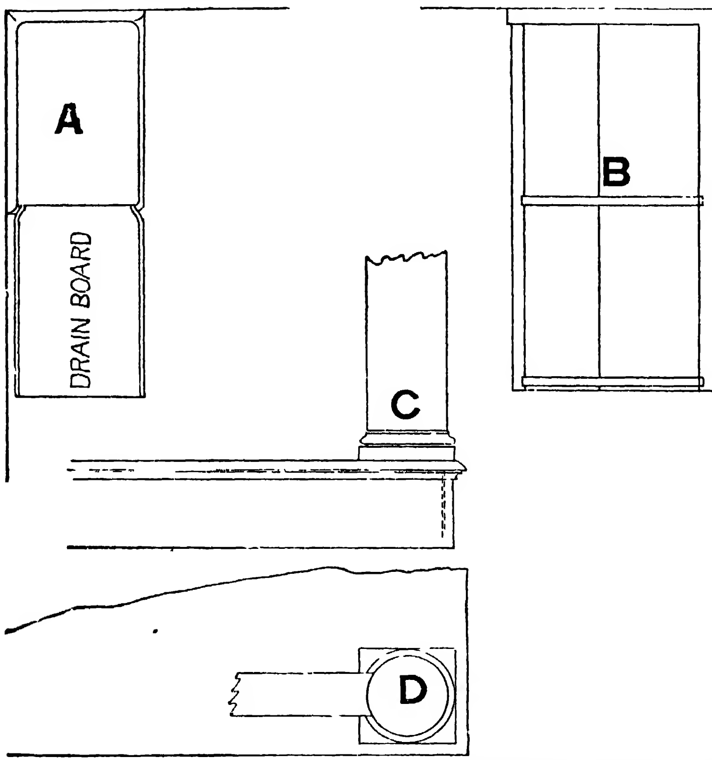


Figs 5,355 to 5,358 —Conventional symbols for representing details on architectural drawings. 2. A, Studding. B, Floor joints C, Wall construction D, Door saddle on threshold.



FIGS 5,359 to 5,362 —Conventional symbols for representing details or architectural drawings. 3. **A**, Concrete filling **B**, Partition bridging. **C**, Bay window **D** Radiators.

In showing plans of stairs, the rise line and not the tread line is shown, this is for accuracy of measurements. When one stairs is under another, parts of each are shown and indicated by "up" and "down" marks. If the partition studding be 4" the floor plan of it shows the additional thickness of walls, not including base. The floor plan of fire place is shown, but

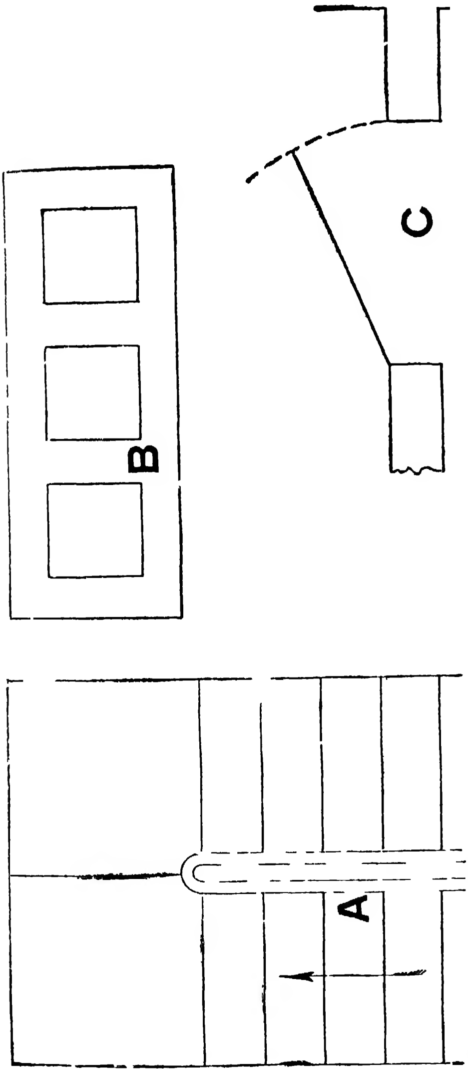


FIGS. 5,363 to 5,366.—Conventional symbols for representing details on architectural drawings. **A,** Sink and drain board. **B,** Wash trays. **C** and **D,** Piazza column.

not generally the mantel. If there be one it is shown in special detail or manufacturer's number.

Views Needed.—The nature of the object to be represented

will determine what views are necessary to completely describe it. Thus to show the design of a fancy hardwood floor, only a plan is required. In the case of a building two or more drawings will be necessary, the number depending on the complexity of the structure.



FIGS 5,367 to 5,369 —Conventional symbols for representing details on architectural drawings **A**, Stairs **B**, chimney. **C**, door

The accompanying illustrations, figs 5,370 to 5,379 illustrate familiar cases which require from one to four views to fully define the object Of course numerous other instances could be shown requiring a larger number of drawings to form a complete set of working drawings or so called "plans"

Development of Surfaces.–The principles of projection

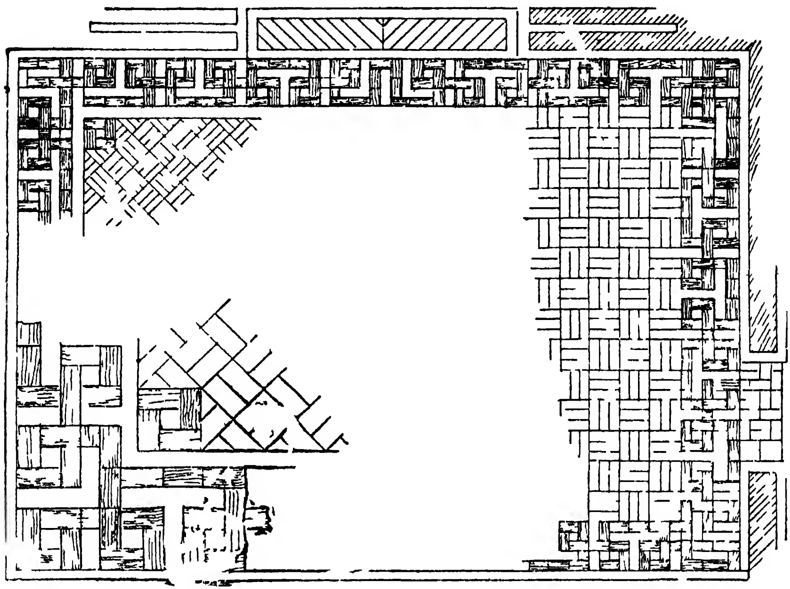
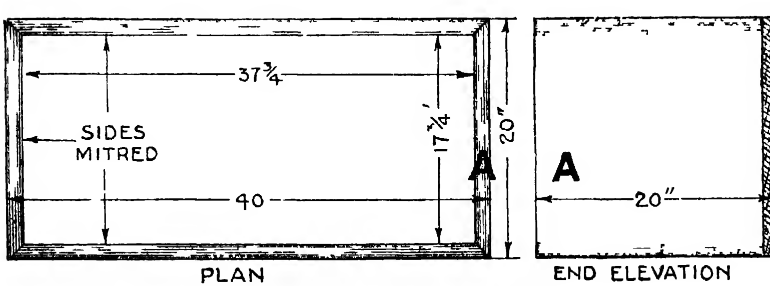
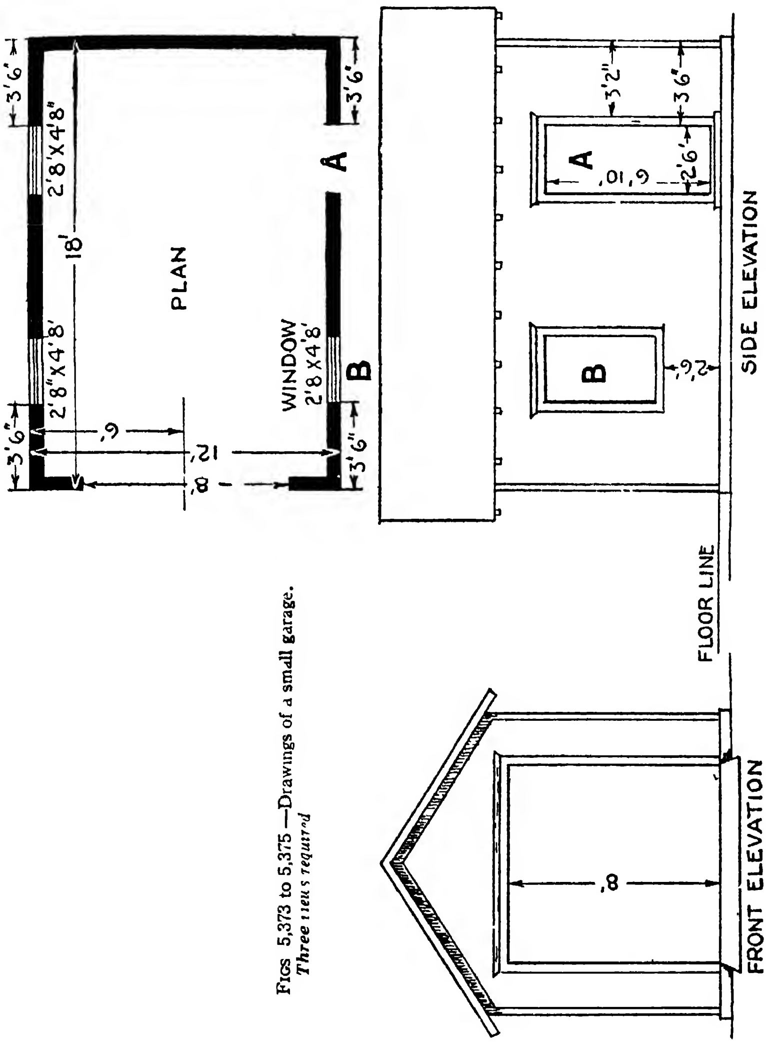


FIG. 5,370.—Plan of fancy hard wood floor *One view required*



FIGS. 5,371 and 5,372.—Drawings of a box *Two views required*

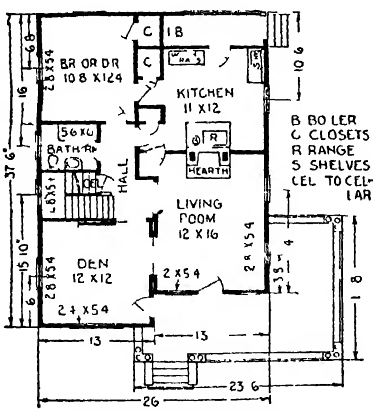


FIGS 5,373 to 5,375.—Drawings of a small garage. *Three views required*

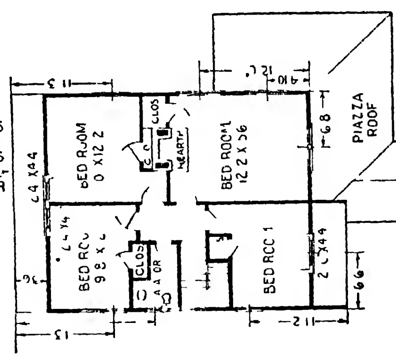
L LUVERS

FRONT ELEVATION

SIDE ELEVATION



FIRST FLOOR PLAN

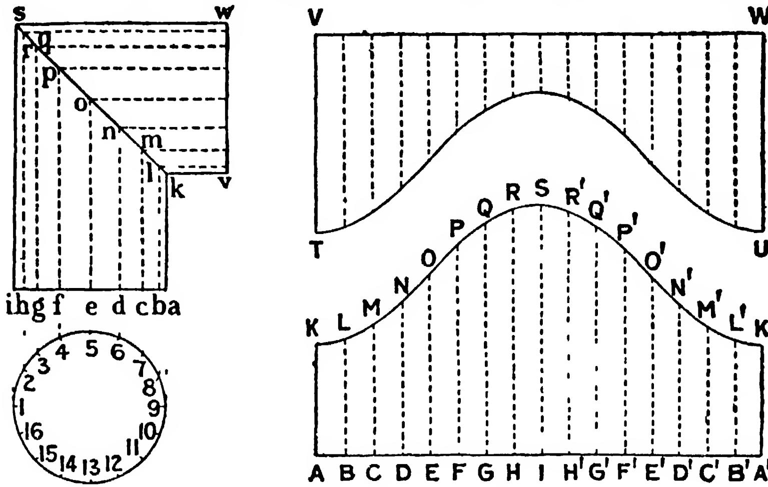


SECOND FLOOR PLAN

FIGS. 5,376 to 5 379 —Drawings of two story house *Four views required.*

already explained may be readily applied to the important problem of development of surfaces.

Whenever it is necessary to make an object of some thin material like sheet metal, as in the case of elbows or tees for



FIGS. 5,380 to 5,383.—Elevation and plan of 90° stove pipe elbow, and development of surfaces

Elbow Patterns.—In all elbow work the difficulty lies in obtaining the correct rise of the mitre line. By the use of a protractor this is overcome and thus the necessity of drawing a complete quadrant is avoided. Following the rule given in the illustration the rise can be easily found when the throat and diameter of the pipe are known. The following table gives the rise of mitre line for elbows of various degrees and of various number of pieces.

ELBOW TABLE

No. of pieces	Divide by	Degree of elbow	Rise of mitre line
2	2	105	52½°
2	2	90	45°
2	2	70	35°
3	4	90	22½°
4	6	90	15°
6	10	90	9°

leader or stove pipe, the surface of the desired object is laid out on sheet metal, in one or in several pieces; these are called the patterns of the object; the pattern being first laid out on the sheet metal and then cut out; when this is done the separate pieces are ready to be fitted together to form the required object.

The method by which the surface of an object is laid out on a plane is called *the* ***development*** *of the object.* A few exercises will sufficiently acquaint the student with the methods used in problems of this character.

Problem 9.—To draw the development of a right, or 90° stove pipe elbow.

A right elbow is made by joining two pieces of pipe for the purpose of forming a right angle. It is really *an intersection of two cylinders of equal diameters;* the center lines of the two cylinders meeting at one point, and as the joint is to be a right elbow, the center lines must be perpendicular to each other.

To develop the surfaces, divide the circumference of the cylinder into any number of equal parts, and through the points of division draw lines parallel to the center line of the cylinder.

On these parallel lines, mark the points which belong to the curve of intersection with another cylinder, or any other figure as happens to be the case, and then roll out the surface of the cylinder into a flat plate.

The rolled out surface will be equal in length to the circumference of the cylinder, and it will contain all parallel lines, which were drawn upon the cylinder, with spaces between them just equal to the actual space between the parallel lines which were drawn upon the surface of the cylinder.

By marking the points of intersection on the parallel lines in the rolled surface, the development of the cylinder or its part is obtained.

In fig. 5,381, the circle showing the circumference of the pipe is divided into any number of equal parts by the divisions 1,2,3, etc. Lines are drawn through these divisions parallel to the center line of the vertical portion of the joint. These lines are ***ak, bl, cm, du,*** etc.

The points ***k, l, m, n, o*** are the points on the parallel lines designating the curve of intersection.

The development of the two branches of the right elbow are shown in

figs. 5,382 and 5,383; the length of the development, VW (or AA′) is equal to the circumference of the figure shown in fig. 5,381. To obtain this length all spaces, 1, 2, 3, 4, etc., laid out upon the circle in fig. 5,381 are set off upon a straight line; these spaces are marked in fig. 5,383 by A, B, C, etc., perpendiculars AK, BL, CM, etc., are drawn through the points A, B, C, etc. The perpendicular AK and K′A′ in fig. 5,383 are each equal to *ak* in fig. 5,381 The second lines on each side of the development, the lines BL and B′L′ are equal to *bl*. Fig. 5,381.

The third lines on each side of the development, the lines CM and C′M′, are equal to the third line cm, fig. 5,381.

The fourth lines in the development are made equal to the fourth parallel in the elevation, fig. 5,381, and in the same manner all other lines in the development are made equal to the corresponding parallels in the elevation of the pipe in fig 5,381.

The middle line, SI in the development is made equal to the line *si*, in the elevation; the points KLMSM′L′K, etc.; thus found, define the position of the curve of intersection in the development of the cylinder.

The required curve is traced through these points; the development AA′K′K is the pattern for the part *aksi* of the right elbow shown in fig. 5,381.

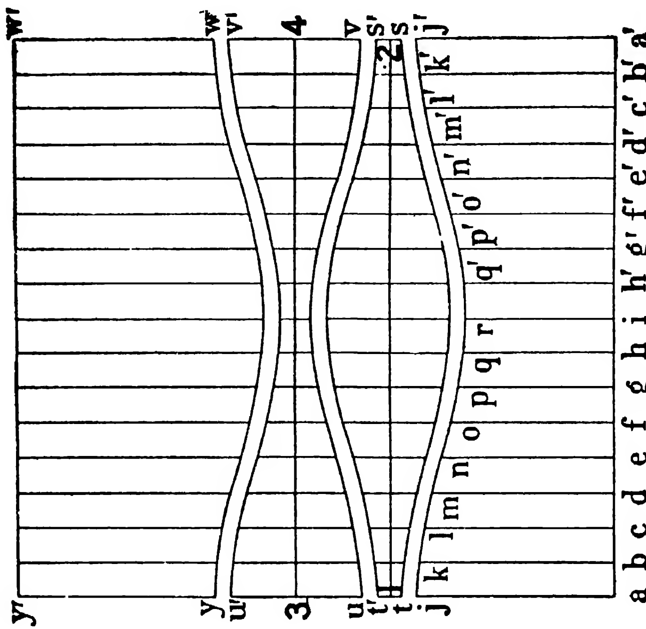
The other part of the elbow is developed in fig. 5,382. It will be readily seen that the figure TVWU is laid out in the manner in which the first development was obtained; in this figure the shortest parallels are laid off above the longest parallels in the first development. This arrangement gives the advantage of cutting out both branches of the right elbow from one square piece of sheet metal without any waste of material.

It will be noticed that the patterns shown in figs. 5,382 and 5,383 do not provide for the lap by which the two branches are held together. A lap of any desired width may be added to the pattern, after it is constructed by drawing an additional curve, parallel to the curve of the above pattern, the distance between the two curves being equal to the width of the desired lap.

Problem 10.– To draw the development of a 90° four part elbow.

A four part elbow is a pipe joint made up of four sections such as is used for stove pipes where it is desired to obtain an easier bend than with the abrupt turn in fig. 5,381.

Fig. 5,384 shows an elevation and plan of the four part elbow. Here the



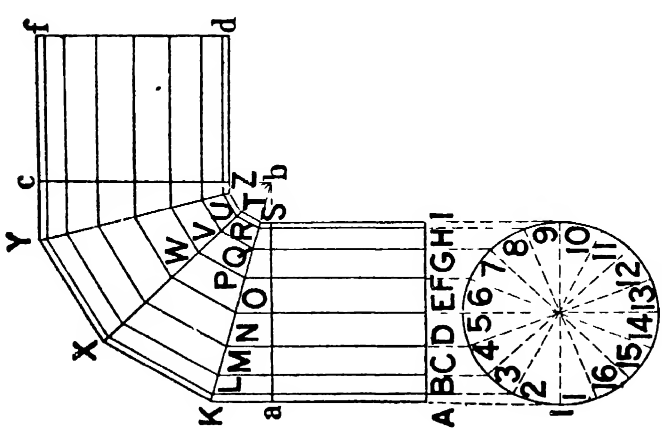


FIG. 5,384.—Elevation and plan of a four part elbow, whose surfaces are developed as shown in fig. 5,385.

FIG. 5,385.—Development of surface of the four-part elbow, shown in elevation and plan in fig. 5,384.

four sections forming the elbow are AKSI, KXTS, XYZT, and Yf*d*Z. Of these four parts, the two larger parts, AKSI and Yf*d*Z are equal. The same is true of the two remaining smaller parts, KXTS and XYZT.

To lay out these parts in the elevation a right angle *abc* is drawn, the sides of which intersect at right angles, the two largest branches of the joint. It is evident that the point *b*, must be equidistant from both pipes.

The right angle *abc*, is divided first into three equal parts and then each one of these parts is divided in turn into two equal parts; the right angle is thus divided into six equal parts, of which Kb*a*, is one part, K*b*X, equals two parts, X*b*Y equals two parts and Y*bc* one part. It will be noticed that this construction does not depend on the diameter of the pipe.

The problem of developing the four part elbow resolves itself into developing two only of its parts, one large branch and one smaller part of the elbow, the remaining parts being correspondingly equal to these.

The circumference of the pipe, fig. 5,384, is divided into sixteen equal parts by the points 1,2,3,4,5, etc.

Through these points are drawn lines parallel to the center line of the pipe which is to be developed.

In fig. 5,385, the vertical branch of the elbow, AKSI (of fig. 5,384), will be taken up for the purpose. The parallels upon the surface of this branch are AK, BL, CM, DN, EO, FP, GQ, HR, and IS. Through the points K,L,M,N,O,P,Q,R, and S, draw parallels for the part KXTS, which will be next developed; some of these parallels are ST, RU, QV, PW.

To develop the vertical branch of the four-part elbow set off, upon a straight line *aa'*, fig. 5,385, sixteen equal parts, which altogether are equal to the circumference of the cylinder, which is to be developed.

Let the division points, *a,b,c,d,e,f*, etc., correspond to the division points, 1,2,3,4, etc., upon the circle, fig. 5,384. Through the points, *a,b, c,d,e*, etc., draw vertical lines equal to the parallel lines drawn upon the surface of the vertical branch of the joint; thus *aj*, is made equal to AK (fig. 5,385), *bk*, equal to BL; *cl*, equal to CM and so on until *ri* is made equal to SI (fig. 5,385).

The part laid out so far is *ajklmnopgri*. This is one-half of the development; the other half, *i'r'j'a'* being exactly the same as the first one, may be laid out in the same way.

The part *tt'ss'* is the development of the small part of the elbow. It is evident that its length, *ts*, must be equal to the circumference of the pipe in the elbow The lines in the pattern, *tt'ss'* drawn at right angles to the

center line of it, and bisected by it, are made equal to the parallel lines, ST, RU, QV, PW, etc., drawn upon the surface of the part, KXTS, fig. 5,385.

It is plain that the part, *uu'vv'* is equal to the part *tt'ss'*, with the difference that the small parallels in it are laid out above the large parallels in the other part; in the same manner, the part *yy'ww'* is equal to the part *aja'j'*.

Laying out the pattern in this manner makes it possible to cut out the complete elbow from one square piece of metal, *ay'w'a'*. The spaces between the patterns are left for laps, which are necessary for joining all parts.

Problem 11.—To draw the development of a tee pipe in which all branches are of equal diameter.

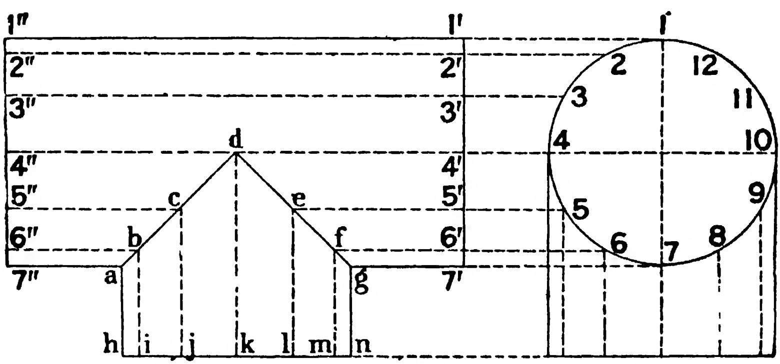


FIG. 5,386 —Side and end elevations of a tee pipe, where surfaces are developed as shown in fig. 5,387 and 5,388, case, where diameter of all three outlets are the same.

Front and side elevations of the tee are shown in fig. 5,386. As seen, it is made by the intersection of two cylinders of equal diameter. The section of the cylinders is represented in the front view by two 45-degree lines *ad* and *dg*.

To develop the pipes divide the circle in the end view of fig. 5,386, into any number of equal parts, in this case let it be twelve parts.

The greater the number of these divisions the more accurate will be the resultant pattern.

Through the divisions 1,2,3, etc., draw horizontal lines cutting the

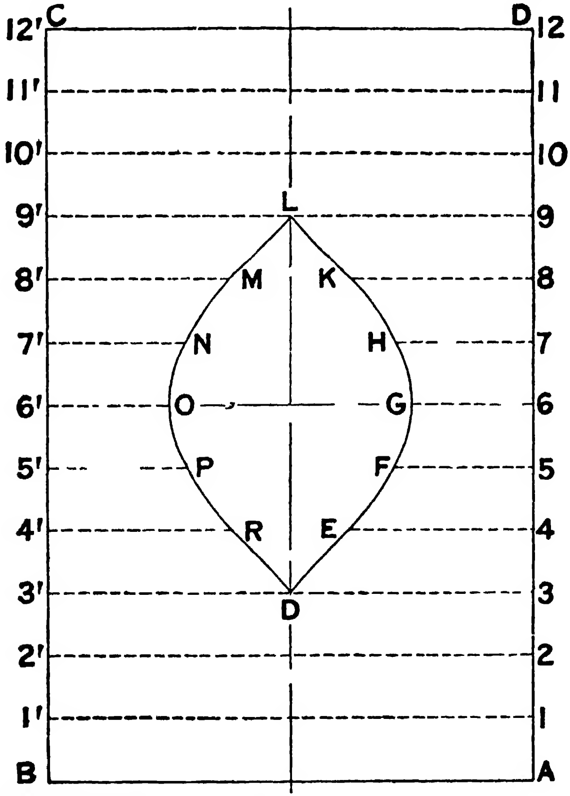


FIG 5,387 —Development of run of tee pipe

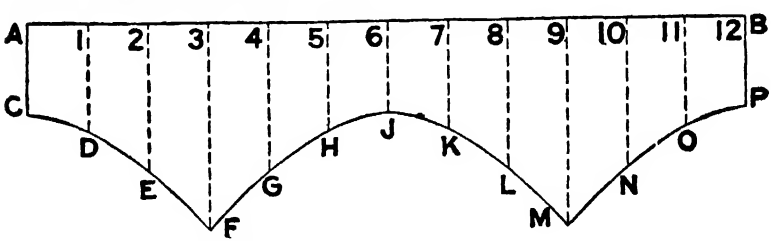
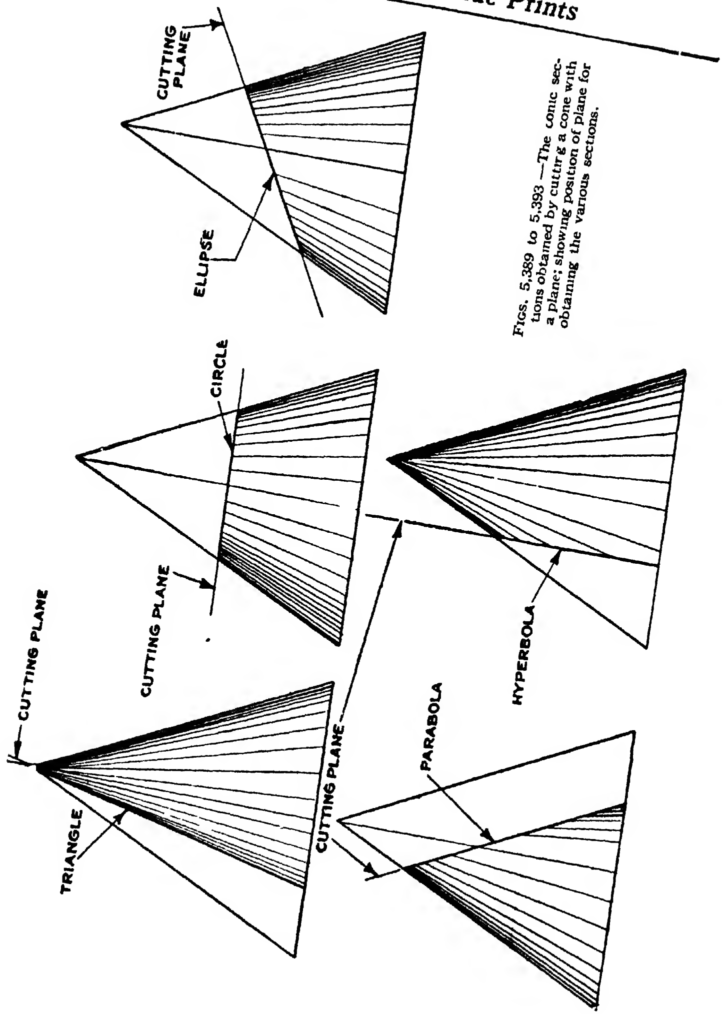


FIG 5 388 —Development of outlet or branch of tee pipe.



FIGS. 5,389 to 5,393.—The conic sections obtained by cutting a cone with a plane; showing position of plane for obtaining the various sections.

horizontal cylinder in the side view in the points 1″1′, 2″2′, 3″3′, 4″4′, 5″5′, 6″6′, 7″7′; the line 4″4′ just meets the lines of the section in the point *d*.

The line 5″5′ cuts the lines of the section in the points *e* and *c*, the line 6″6′ cuts the section lines in the points *f* and *b*, and the line 7″7′ cuts the lines of the section in the points *g* and *a*.

Draw vertical lines through the points *a,b,c,d,e,f,* and *g*. After all these lines are drawn we have all that is necessary to complete the development of the cylindrical surfaces.

Fig. 5,387 shows the development of the horizontal cylinder; the rectangle ABCD, is equal to the cylinder surface. The curve ODGL, is cut out within the rectangle for the joint which is the outline of the opening, into which the vertical cylinder will fit.

The rectangle ABCD, has one side AB, equal to the length of the horizontal cylinder, fig. 5,386, the other side AD, is equal to the circumference of the circle, show in the end view of the horizontal pipe, fig. 5,386. The twelve divisions marked on the circle are set off on the straight line AD, fig. 6,387, so that together they are equal to the circumference of the circle.

The outline of the opening for the intersection of the horizontal pipe with the vertical branch is laid out in the middle of the rectangle ABCD, in the following manner: On the middle line 6′6 are set off the distances 6′O and 6G each equal to *g*7′ (or *a* 7″) in fig. 5,386, on the lines 5′5 and 7′7 are set off the distances 5′P, 5F, 7′N and 7H each equal to the distance 6′*f*, fig. 5,386 (or *b*6″). The distances 4′R, 4E, 8K and 8′M are set off on the lines 8′8 and 4′4 to equal the distance *e*5′ (or *c*5″) of fig. 5,386. The lines 3′3 and 9′9 are touched by the curve of intersection in their center at points D and L.

There still remains to be drawn the development of the vertical branch of the tee-pipe; this is found in the same manner as the horizontal part *i.e.*, by laying out the surface of the vertical cylinder; that is, by making it equal in length to the circumference of the circle showing the end view of the cylinder. The development is shown in fig. 5,388.

On the line AB, are set off the twelve parts of the circumference and in each one of these divisions is erected a perpendicular to the line AB; on these perpendiculars are laid off successively the length of the vertical lines drawn on the surface of the vertical branch; the lines AC, fig. 1 D, 2E, 3F, G4,5H and 6J in fig. 5,388, are equal correspondingly to the lines *ah, bi, cj, dk, el, fm* and *gn*, in fig. 5,386.

Thus one-half of the development ACJ6 is constructed; the other 6JPB is exactly equal to the first part.

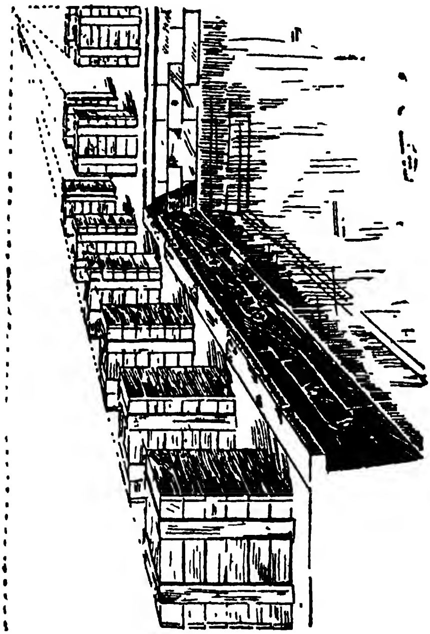


FIG. 5,394.—Perspective view with vanishing point at side of drawing.

FIG 5,395.—Perspective view with vanishing point at center of drawing.

The method employed in these cases may be applied to nearly all developments of cylindrical surfaces; it consists in drawing on the surface of the cylinder, which is to be developed, any number of equidistant parallel lines. The cylindrical surface is then developed and all parallel lines drawn in it. *By setting off the exact lengths of the parallel lines a number of points are obtained, through which may be traced the outline of the desired development*

It has been noted in fig. 5,386, that the intersection of two cylinders of equal diameters—their arcs intersecting each other—will always appear in the side view as straight lines at right angles to each other. If one cylinder be of a smaller diameter than the other then the intersection will be a curve.

Perspective Drawing.—This is the art of representing objects as they appear to the eye at a *definite* distance from the object. In orthographic (perpendicular) projection the views represent the object as seen when the eye is *infinitely* distant. By the perspective method then the lines drawn from points on the object to the eye converge and intersect at the point of sight.

Before beginning the study of perspective projection it is well to consider some of nature's phenomena of perspective. These phenomena become more apparent in attempting to sketch from nature. One effect is that the size of an object diminishes as the distance between the object and the eye increases. If several objects of the same size be situated at different distances from the eye, the nearest one appears to be the largest and the others appear to be smaller as they are further and further away.

At last the distance between the lines become zero and the lines appear to meet in a single point. This point is called the *vanishing point* of the lines, as shown in figs. 5,394 and 5,395.

By closer investigation of a perspective drawing it is found that

1. The limit of vision is a horizontal line called the *horizon*, situated at the height of the eye.

2. Objects of equal size appear smaller with increasing distance.

3. Parallel lines converge into one point, called *vanishing point*. For horizontal lines this point is situated at the height of the eye, that is, it lies in the horizon.

4. Vertical lines appear vertical.

5. The location of the observer's eye is called the *point of sight* and is located in the horizon.

When an object in space is being viewed, rays of light, called *visual rays*, are reflected from all points of its visible surface to the eye of the observers.

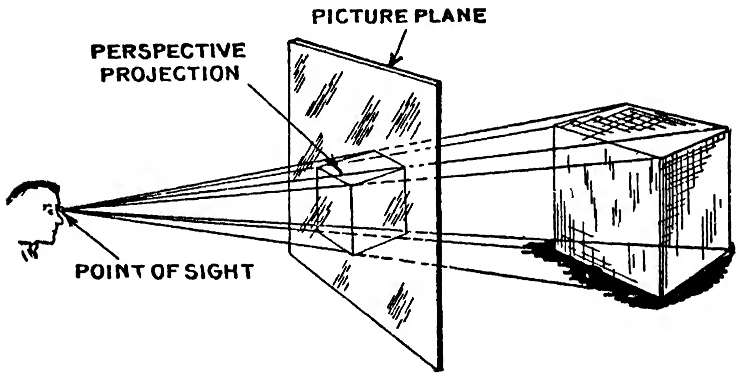


FIG. 5,396.—Picture plane illustrating principles of perspective.

If a transparent plane, fig. 5,396, be placed between the object and the eye, the intersection of the visual rays will be a projection of the object upon the plane. Such projection is called the *perspective projection* of the object. The plane on which the projection is made is called the *picture plane*. The position of the observer's eye is the *point of sight*

This principle is illustrated by models where red strings represent the rays, piercing a glass plate.

Perspective by Means of Plan and Elevation.—This method of perspective can be put to practical use if a perspective

projection be obtained in plan and elevation and then an orhtographic projection to obtain the perspective.

Fig. 5,389 shows a prism in plan and elevation, its front face making an angle with the picture plane. As a general rule, the object is placed behind the picture plane with one of its principal

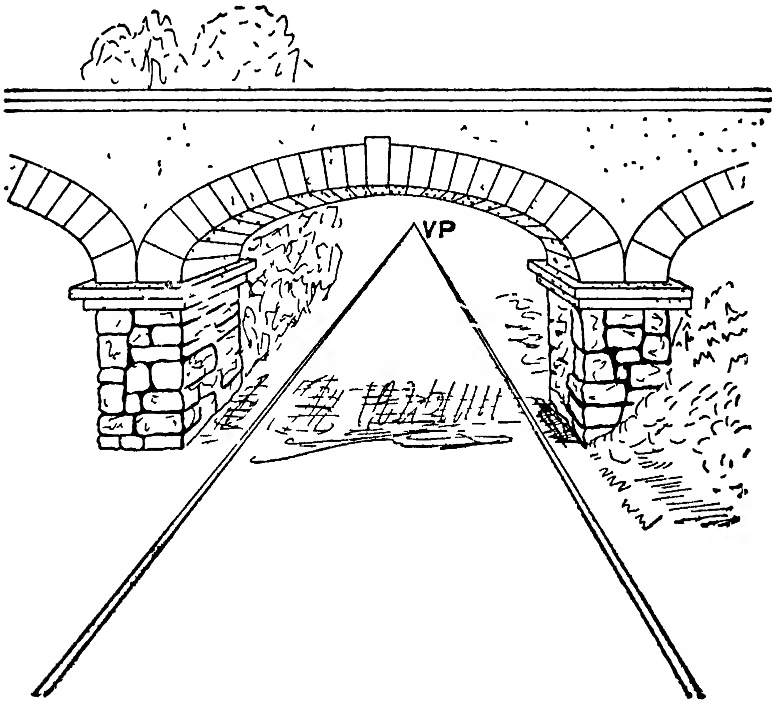


FIG 5,397 —Prospective view looking through arch of bridge, showing vanishing point in the center.

vertical lines lying in the picture plane. P, is the point of sight (the observer's eye). Its distance A, from the picture plane in plan depends a great deal on the size of the object and it is important that the best viewpoint is obtained.

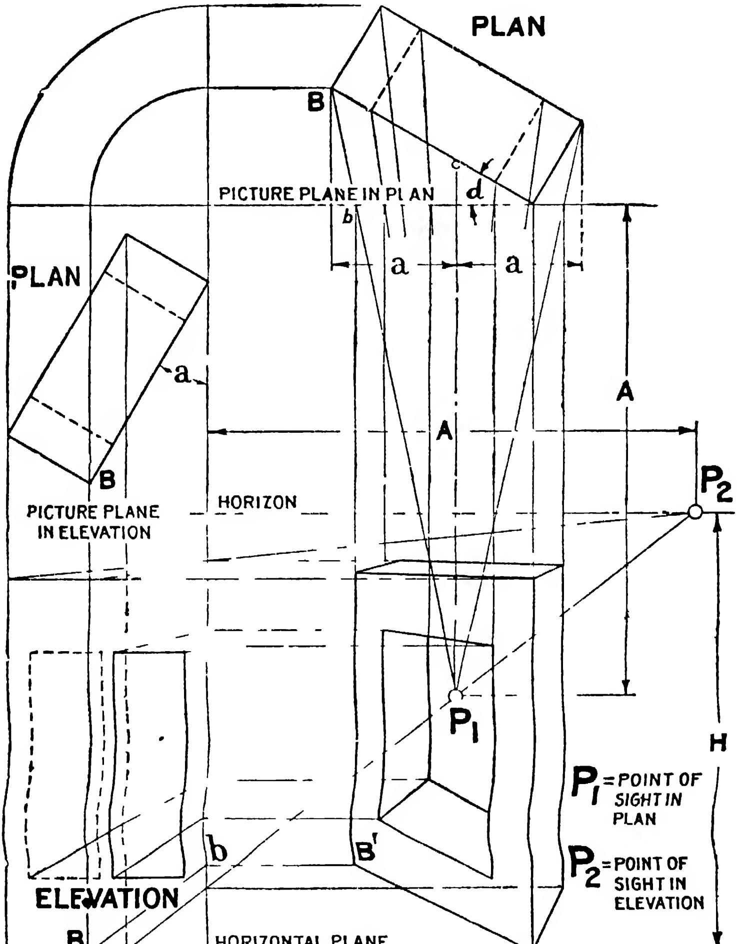


FIG 5,398 —Perspective of a prism by means of plan and elevation. ***To obtain the perspective*** of any point of the object, for instance B, draw the visual ray in both plan and elevation to P_1 and P_2, respectively. From the point of intersection *b*, in the picture plane (in plan and elevation) project perpendicularly and thus obtain the point B_1, as perspective picture of the point B, of the object In this manner all the other points of the perspective are obtained. This method of construction requires no further explanation and may be applied wherever plan and elevation is obtainable.

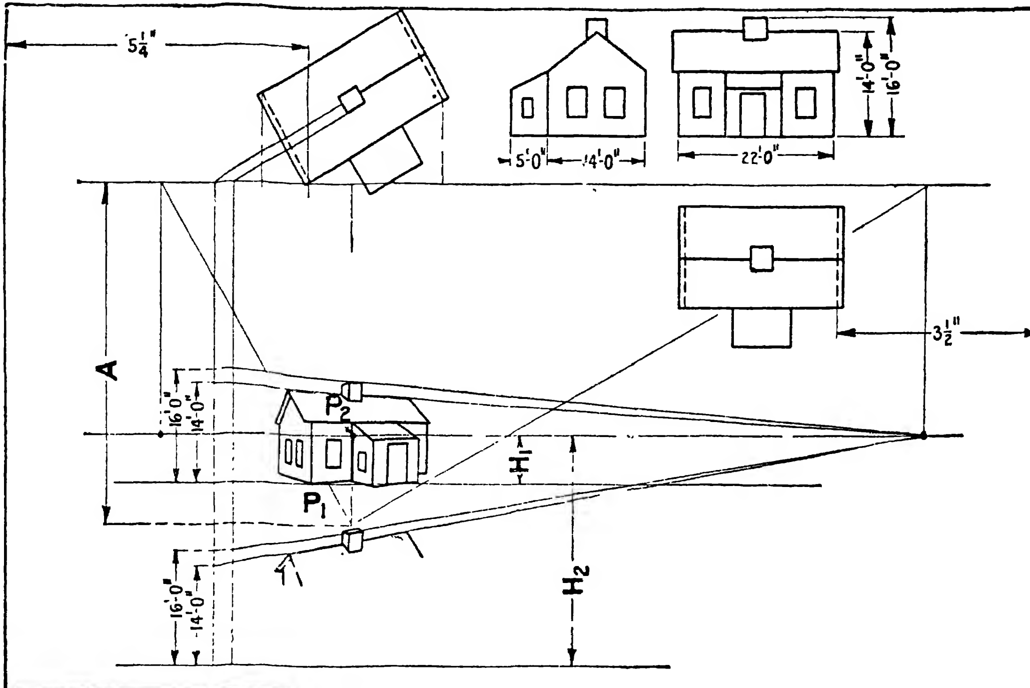


FIG. 5,399.—Perspective of a house. The projections are given, long side of house making an angle of 30° with the picture plane. Nearest vertical edge of house to lie in the picture plane Two perspective views of the house shall be obtained, the house being viewed from two different points. Their common distance in plan A = 46'. The distances H_1 and H_2 of the point of sight above the horizontal shall be 6'-6" and 31'-6", respectively. The construction of both views is exactly the same. The fact that the porch projects in part in front of the picture plane makes no difference in the construction of the perspective projection.

If a house about 40′ high is to be sketched, the point of sight should be taken about 80′ from the picture plane. A good rule to follow is to make this distance about twice the greatest dimension. When large objects are to be represented the best results are obtained when the point is taken nearly in front of the object.

The distance of the horizon from the horizontal plane equals the height of

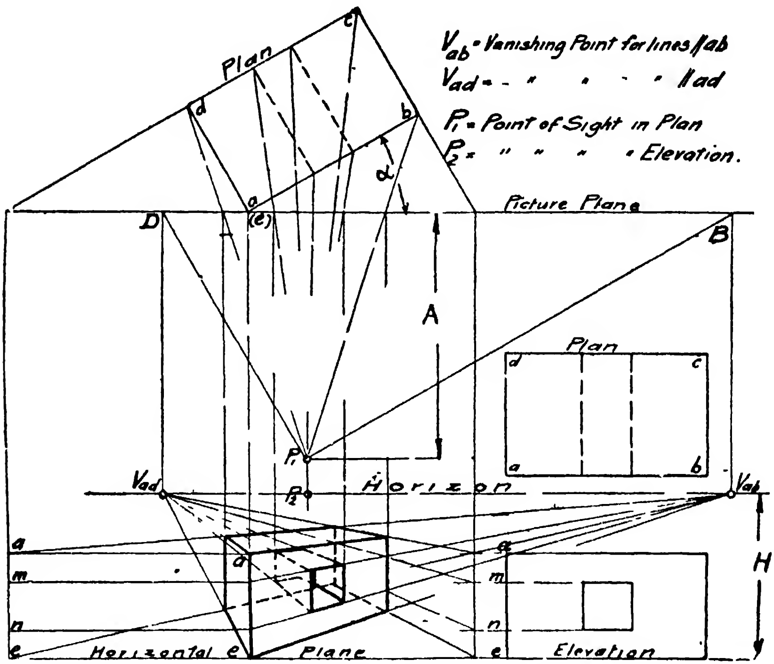


FIG. 5,400.—Perspective of rectangular prism by means of two vanishing points.

the eye above ground and may be taken = 5′ – 3″. For high objects this distance may be increased and for low objects decreased. In the present case it is shown slightly above the object. P, is assumed on a vertical line half way between two lines dropped from the extreme edges of the diagram. This is not necessary, but it usually insures a more pleasing perspective projection.

The method of obtaining the perspective is explained under the illustration.

Perspective by Means of Two Vanishing Points.—An example of this method of perspective is shown in fig. 5,400, which illustrates a rectangular prism in plan and elevation resting upon a horizontal plane.

The first step will be to redraw the plan, same as with the first method, behind the picture plane in plan, with the vertical line *ae*, lying in the picture plane and turned so that its long side makes an angle a (30°) with the picture plane The point of sight P_2 is at a distance H, above the floor and is located at the same height as the horizon

Next, find the vanishing points for the different systems of lines in the object There are three systems of lines in the prism V*ab* and V*ad*, are

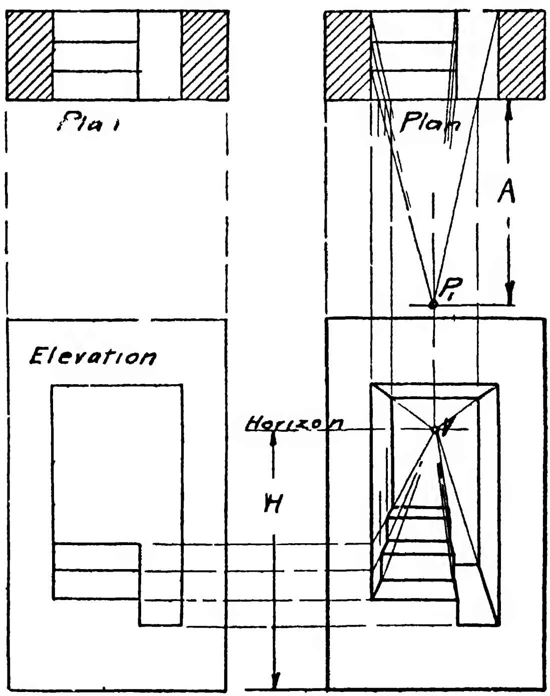


FIG 5,401 —Perspective of a prism by means of one vanishing point

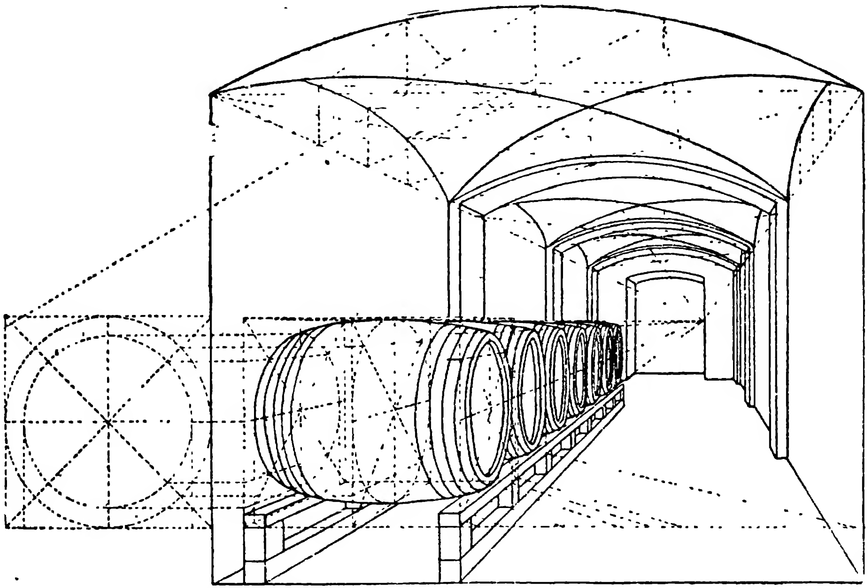


FIG. 5,402.—Perspective of a row of barrels by means of one vanishing point.

found by drawing lines P_1B and P_1D, through P_1 parallel to *ab* and *ad* of the diagram and dropping vertical lines from the intersection of these lines with the picture plane (B and D) to the horizon giving the vanishing points V*ab* and V*ad*. The third system of lines embraces the vertical lines which are drawn actually vertical and not converging towards one another.

The edge *ae* of the diagram, being in the picture plane, is called the *line of measures*, as it appears in its true size in the perspective view, and from *a* and *e* in the perspective view the lines will vanish at V*ab* and V*ad*, respectively, establishing by intersection with the vertical edges all points desired.

Besides this principal line of measures other lines of measures may easily be established by extending any vertical plane in the object until it intersects the picture plane. This intersection, since it lies in the picture plane, will show in its true size and all points in it will show at their true height above the horizontal plane.

If no line in the object should lie in the picture plane there would not be any principal line of measures,

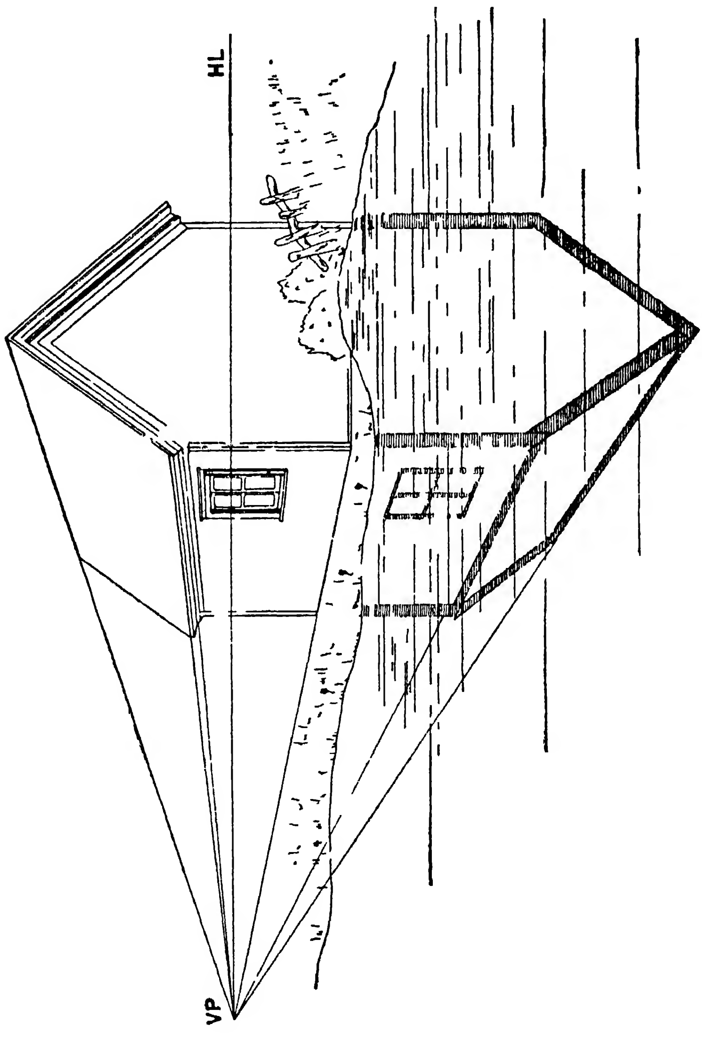


FIG. 5,403.—Prospective view of small building drawn with vanishing point at the left side.

and some vertical plane in the prism must be extended until it intersects the picture plane.

Instead of being some distance behind the picture plane, the prism might have been wholly or partly in front of the picture plane. In any case, find the intersection with the picture plane of some vertical face of the prism. This intersection will show the true vertical height of the prism.

Perspective by Means of One Vanishing Point.—In this method the plan is placed with one of its principal systems of horizontal lines parallel to the picture plane. This system therefore has no vanishing point, and as the vertical system has no vanishing point, only the third system of lines will have a vanishing point.

In fig. 5,401, the vertical face of the prism lies in the picture plane and shows in its true size. Its edges are lines of measures

The construction of the perspective is easily apparent from the illustration.

Another example of perspective by means of one vanishing point is shown in fig. 5,402.

CHAPTER 96

Laying Out

Selection of Site on Lot.—The term *laying out* here means *the process of locating and fixing reference lines which define the position of the foundation and outside walls of a building to be erected.*

Preliminary to laying out (sometimes called "staking out") it is important that the exact location of the building on the lot be properly selected. This involves a careful examination of the ground to determine the character of the soil which will largely determine its sanitary condition and influence on the health of the occupants. The chief object in this examination is to so locate the building as to obtain a dry cellar. In this examination, dig a number of small deep holes at various points, extending to a depth a little below the bottom of the cellar.

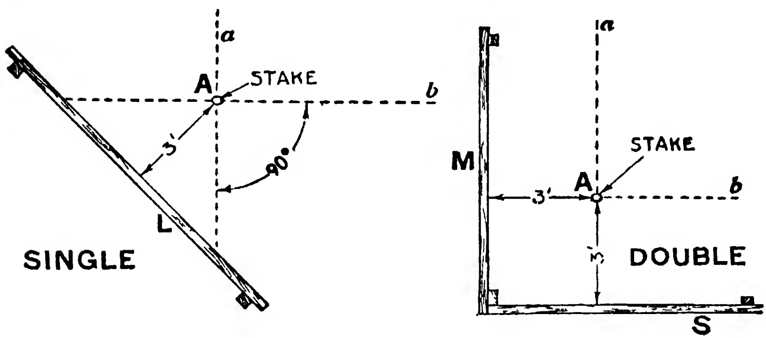
The "ground water" which is always present near the surface of the earth, will, if the holes extend down to its level, appear in the bottom of the holes This water stands always nearly at the same level, so that it is not met with so near the surface of a slight knoll or other elevation as in the case of a depression.

If possible in selecting the site for the house it should be so located that the bottom of the cellar is above the level of the ground water. This means locating the building if necessary at some elevated part of the lot, or reducing the depth of excavation. It is better to alter plans than to have a damp cellar.

Laying or "Staking" Out.—After the approximate location has been selected the next step is *to lay out the building lines.* That is, the position of the corners of the building must be marked in some way so that when the excavation is begun, the workmen may know the exact boundaries of the cellar walls.

There are two methods of laying out the lines:

1. With lay out square.
2. With surveyor's instrument.
3. By method of diagonals.



FIGS. 5,404 and 5,405.—Single and double batter boards. After locating a corner of the proposed building by driving down a stake A, erect either a single batter board as in fig. 5,404, or a double batter board, as in fig. 5,405. Note the general direction of the building lines A*a*, and A*b*, and locate the single board L, or double board MS, 3 feet back of the stake and with posts far enough apart so that the lines A*a*, and A*b*, (produced) will cut the boards at least 30 inches from the posts.

Whereas the first method will do for small jobs, the efficient carpenter or contractor will be provided with an architect's level or transit, with which lines may be laid out with great precision and more conveniently than by the makeshift first method.

The Lines.—There are several lines which must be located

at some time during construction and they should be carefully distinguished. They are:

1. The *line of excavation*, which is outside of all.
2. The *face line* of the basement wall inside of the excavation line, and in the case of a masonry building.
3. The *ashlar line*, which indicates the outside of the brick, or stone walls.

In the case of a wooden structure only the two outside lines

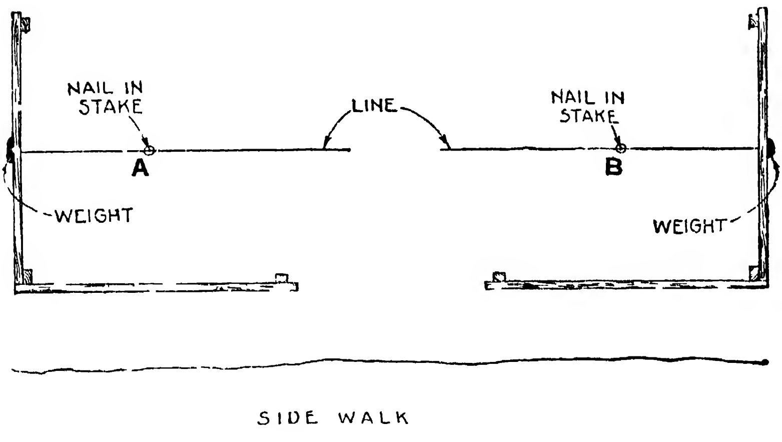


FIG. 5,406 —Location of front line of building. A, and B, are the two stakes with a nail driven in each, the distance between these nails being the length of front side of building.

need be located and often only the line of the excavation is determined at the outset.

Laying Out with Lay Out Square.—Start to lay out from any point on the ground at which it is desired to place one corner of the building, by driving a stake at this point. Back of this point (far enough to be outside of the excavation line—about 3 ft.) erect a batter board as shown in figs. 5,404 or 5,405.

Suppose that the building be of rectangular shape and that the front of the building is to be parallel with the street.

Starting at the stake A, fig, 5,405 (using double batter boards) lay out a line parallel with the sheet as in fig 5,406, driving a stake B, at a distance equal to the length of the front of the building The exact location of the ends of the line may be indicated by a nail driven into each stake Since the building is of rectangular shape lines must be laid out at A and B, at 90° or right angles to the line AB

The right angle is obtained by means of a large square constructed as in

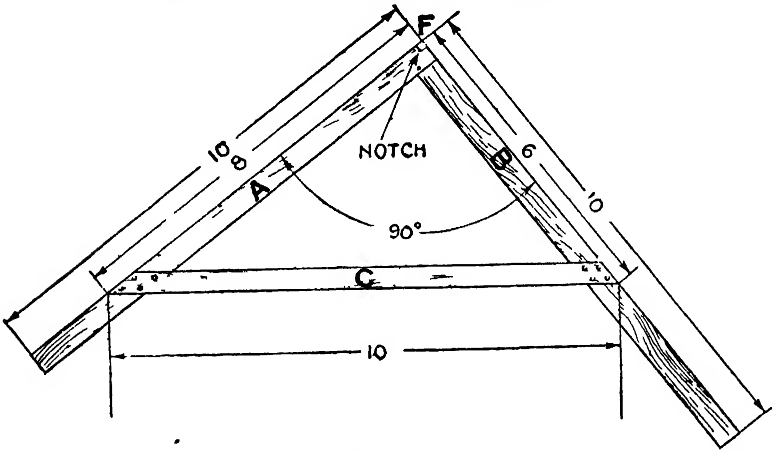


Fig 5,407—Large lay out square *In construction,* get three 1 × 6 boards A B C 10 feet long Square off ends of A and B with precision (if this make these boards a little less than 10 feet it does not matter) Mark off with care 8 feet on A 6 feet on B and 10 feet on C (if C be short of 10 feet get a longer board and mark off accurately 10 feet) Now place A, on top of B and C on top of both and fasten with nails If this work be done with precision an accurate right angle will be obtained at F A much better job is to make a lap joint at F so that surfaces A and B will lie in the same plane The square should be notched at F, so the stake will not prevent placing it under the lines

fig. 5,407. The figure shows the right way to make the square by having boards A and B the same length It must be evident that if A and B, be cut off where they are joined to C, making B shorter than A, the extra length of A does not add to the precision, as the latter depends upon the length of the shortest side This square is shown in fig 5,408 at corner A

In using the square, the legs and lines are brought into alignment by means

of a plumb bob. Having thus placed one leg under line AB, line AD, is adjusted on the batter boards until it is directly over the nail in stake A, and the other leg of the square. When the four lines AB, BC, CD, and DA, are thus located and the work checked by measuring diagonals AC and BD, (which must be equal), the lines are located permanently by sawing vertical slits in the batter boards into which the lines are placed. Stakes B,C,D, may now be driven at the corners, using a plumb bob to locate on the ground the intersections of the lines.

Fig. 5,409 shows use of the plumb bob and fig. 5,410 method of perma-

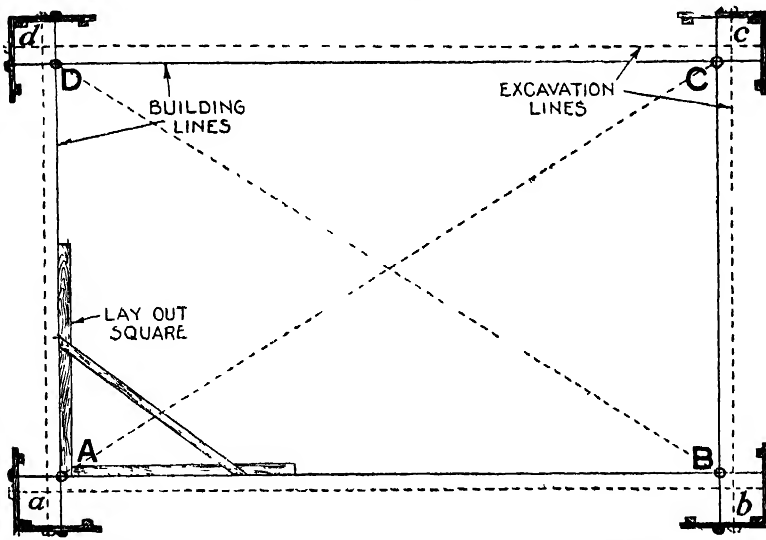


FIG. 5,408 —Lay out for building showing batter boards (*a,b,c,d,*) lines and stakes A,B,C,D, in position, also lay out square placed at A, to locate line AD, at right angles to AB.

nently locating lines by sawing slits in the batter boards as slits L and M, for lines AD and AB.

After permanently locating the four building lines, mark off on the batter boards the distance the excavation lines are from the building lines and cut slits at these points, as in fig. 5,410.

In excavating, the lines are placed in the outer or excavation slits, and may be later moved into the other slits as the work progresses. These lines are held taut by means of weights as shown.

Laying Out with Surveyor's Instruments.—The architect's level, or a transit may be used, and as these are instruments of precision the work of laying out is more accurate than where the lay out square is employed.

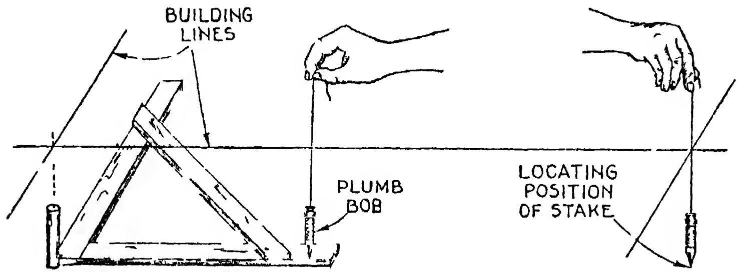


FIG 5,409 —Method of bringing lines and lay out square into alignment and location of point for corner stake by means of a plumb bob

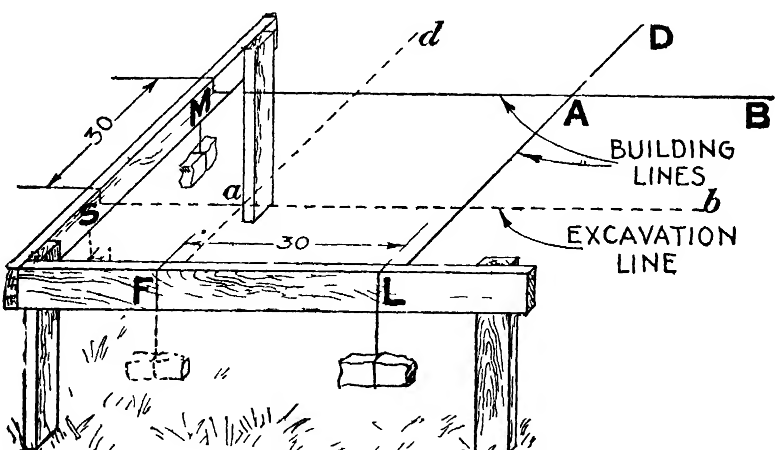


FIG 5,410 – Permanent location of lines by means of slits cut in the batter boards Slits L, and M, locate the building lines When the work is first started the boundaries for the excavation must be indicated These extend some distance outside the building lines Measure off this distance (say 30 inches) on the batter boards as shown (MS and LF,) giving points M, and F, at which slits should be sawed Evidently by placing the lines in these outer slits the excavation boundaries are obtained for the excavation

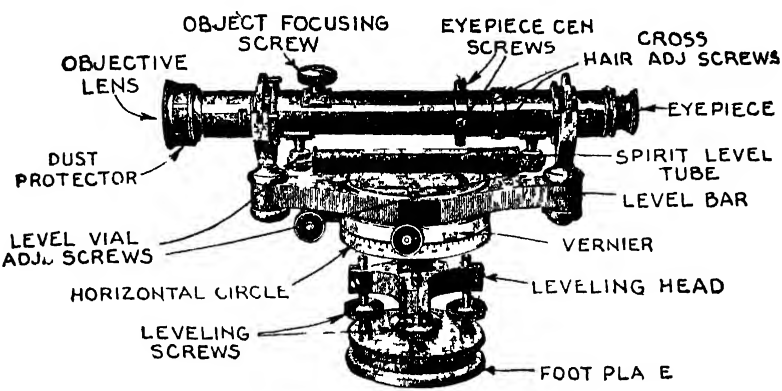


FIG. 5,411.—Contractor's or architect's level. *The various parts* are named in the illustration. This instrument differs from the transit shown in fig. 5,410 in that it has no attachment for measuring vertical angles. This is not serious however since the builder seldom needs such an attachment.

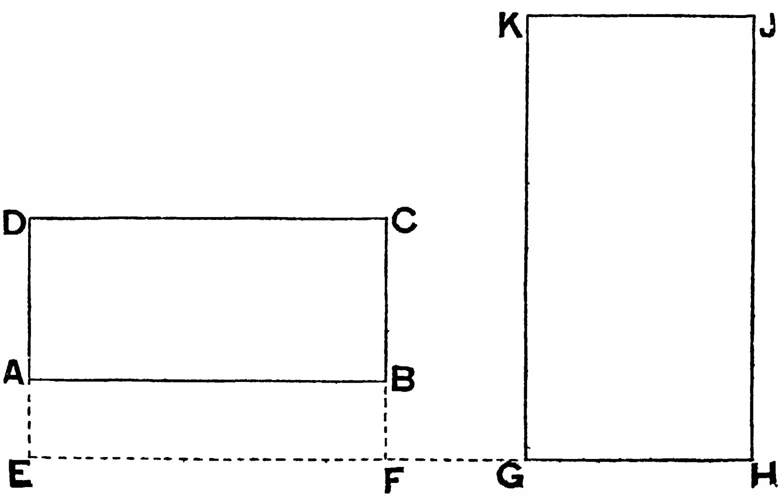


FIG. 5,412.—Diagram illustrating method of laying out with surveyor's instruments.

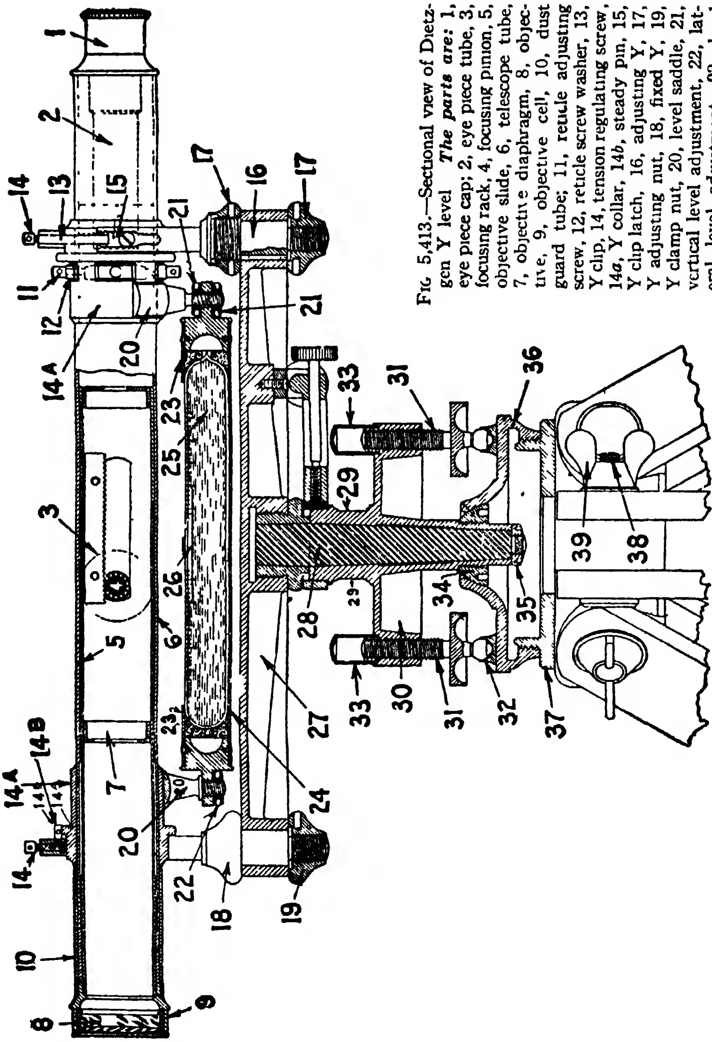


FIG. 5,413.—Sectional view of Dietzgen Y level *The parts are:* 1, eye piece cap; 2, eye piece tube, 3, focusing rack, 4, focusing pinion, 5, objective slide, 6, telescope tube, 7, objective diaphragm, 8, objective, 9, objective cell, 10, dust guard tube; 11, reticle adjusting screw, 12, reticle screw washer, 13, Y clip, 14, tension regulating screw, 14*a*, Y collar, 14*b*, steady pin, 15, Y clip latch, 16, adjusting Y, 17, Y adjusting nut, 18, fixed Y, 19, Y clamp nut, 20, level saddle, 21, vertical level adjustment, 22, lateral level adjustment, 23, level ends, 24, level tubing, 25, level vial, 26, level bubble, 27, Y bar 28, center spindle, 29, center sleeve, 30, leveling arm 31, leveling screw, 32, leveling screw ball cups, 33, dust caps, 34, half ball, 35, center nut, 36, leveling screw plate, 37, tripod head, 38, tripod bolt, 39, tripod nut.

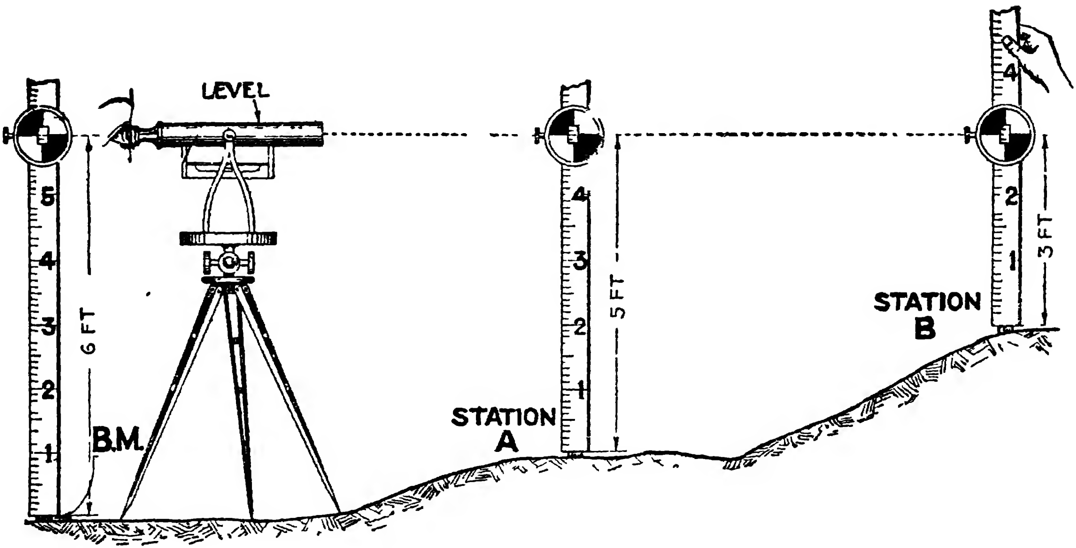
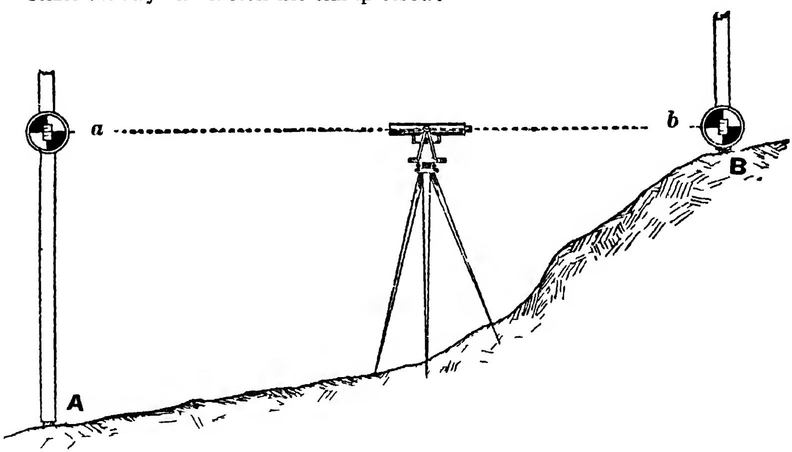


FIG 5,414 —General principle of leveling *The elevations of all points above a given starting point of referenace, called a bench mark* (**B. M.**), *is obtained* In the figure, **A** and **B** are two points whose levels or difference in level are to be determined The instrument is placed midway between the **B M** and station **A**, and the height of the line of sight through the instrument determined with respect to **B. M.** by leveling the telescope and sighting on a rod divided into feet, inches and fractions of an inch Say this is 6 ft Now sighting on the rod placed on station **A** and then on station **B** readings of 5 ft and 3 ft respectively are obtained Hence, for these readings station **A** = 6 − 5 = 1 ft higher than the **B. M.**, station **B** is 6 − 3 = 3 ft higher than the **B. M.**, and the difference in elevation between station **A** and **B**, = 5 − 2 (or 3 − 1) = 2 ft By a similar process the difference in elevation between any number of points is determined

In fig. 5,412, let ABCD, be a building already erected, and it be required to lay out the site of a building GHJK, at a given distance from and at right angles to, the first building.

Level up the instrument at E, making AE, as shown by the point of the plumb bob below the instrument, equal to the distance the side of the new building is to be from AB. Make BF, the same length as AE, and sight on a flag pole or rod placed on F. Make the vertical cross wire cut the stake exactly and fasten the clamp screw.



FIGS 5,415 —Leveling 1. Between two points whose difference in level is less than length of rod. Set up and level instrument at some point about half way between the two points. Have rod man hold rod vertically on one of the points and move target up and down till its center coincides with the cross wires of the level. Take reading which gives distance Aa. Similarly, turn telescope on its spindle, hold rod on the other point and take reading which gives the distance Bb. Evidently the difference in level is equal to the difference in the readings that is Aa - Bb.

Then have an assistant carry the flag pole to G, making FG, the required distance of the new building from the side BC. Have him move the pole from side to side until it is exactly in line with the vertical cross wire. Locate H, on the same line, making GH, the desired length.

Then place the instrument over the point G, and level it up. Focus the telescope on the flag pole placed at E, or F, and fasten the clamp screw. Turn the horizontal circle until one of the zeros exactly coincide with the

vernier zero. Loosen the clamp screw and turn the telescope and vernier to 90 degrees. Any point which the vertical cross wire cuts, as K, will be on the side of the proposed building. GK, may be made the required length. The other side GH, is checked up by turning the telescope until the vernier zero corresponds with the other zero on the circle. If the work has been correctly done, H, will be on the point located before.

The level may be used in setting floor timbers, in aligning shafting, locating drains, in ascertaining the height of springs and the depth of wells.

Method of Diagonals. All that is needed in this method is the twine for the lines, stakes and a tape measure. Here the

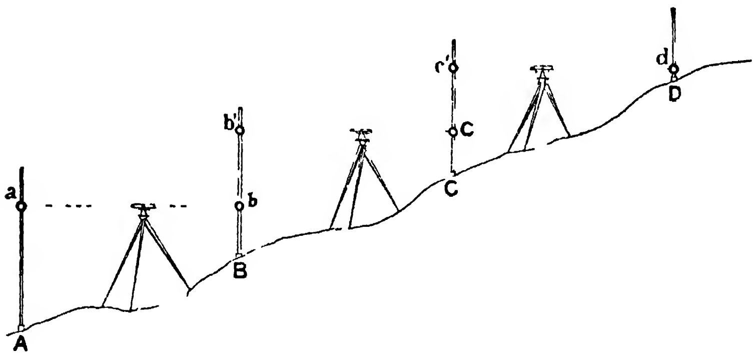


FIG. 5,416.—Leveling, 2. Between two points whose difference in level is greater than the length of the rod. Divide the distance between the two points into sections of such length that the difference in level between the dividing point A, B, C, called *stations*, shall be less than the length of the rod. Set up and level between A and B, and measure distance Aa called back sight (B. S.); then reverse the telescope and take reading *Bb* called a foresight (F. S.). Next set up the level between B and C and similarly take readings *Bb* and *Cc*. Repeat operation between C and D taking readings *Cc* and *Dd*. Evidently the difference in level between station A and D, is equal to the *sum of the differences between the intermediate stations*, that is this difference equals (*Aa* − *Bb*) + (*Bb* − *Cc*) + (*Cc'* − *Dd*) or expressed in another form (*Aa* + *Bb* + *Cc*) − (*Bb* + *Cc* + *Dd*).

right angle between lines at corners of a rectangular building is found by calculating the length of the diagonal which forms the hypothenuse of a right angle triangle with two adjacent sides. By applying the following rule the length of diagonal or hypothenuse is found.

***Rule.**—The length of the hypothenuse of a right angle triangle is equal to the square root of the sum of the squares of each leg*

Thus, in a right angle triangle ABC, of which AC, is the hypothenuse

$$AC = \sqrt{AB^2 + BC^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

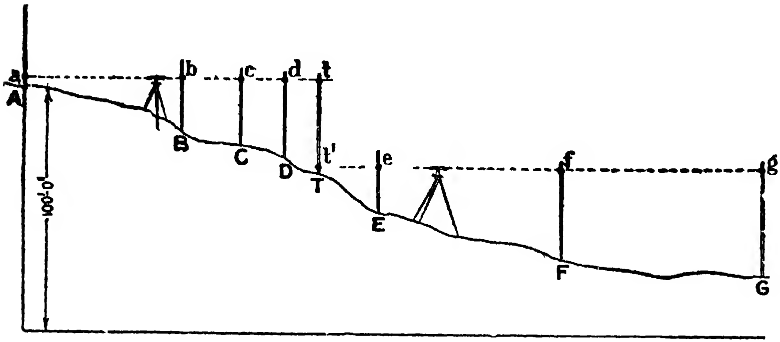


FIG 5 417 Leveling **3.** Finding the relative elevations of several points Assume a datum or reference line below the elevation of the lowest station and refer all elevations to this line Start at some permanently fixed point as a mark on building top of hydrant etc this is called a *bench mark* Let A be the bench mark and assume datum line 110 feet below level of A Field notes are taken corresponding to the surveying operations Starting with the instrument between A and B and taking a back sight on A the distance A*a* is found to be 4 2 ft which added to 100 gives the height of the instrument Next take fore sights on B C and D and record them in proper column It is evident from the figure that readings B*b* C*c* etc substracted from the height of the instrument will give the elevation at B C etc This is done and the results recorded in the proper column The ground falls away so rapidly beyond D that it is necessary to set up the level further along and establish a new height of instrument This is done by holding the rod at some convenient point as at T called a *turning point* and taking a fore sight which measures the distance T*t* (9 2) The level is then set up in its second position between E and F and a back sight taken on the rod in the same position which gives the distance T*t* (4 1) Then the distance *t t* = 9 2 — 4 1 = 5 1 and this subtracted from the previous height of instrument gives the new height which is 101 2 — 5 1 = 99 1 A back sight is now taken on E and fore sights on F and G These are recorded in the proper columns and the elevations found by subtracting these distances from the new height of instrument The horizontal distances between the stations are measured with a tape and recorded in the second column In plotting a cross section from notes kept in this way the datum line is first drawn and perpendiculars erected at points corresponding to the different stations The proper elevations are then indicated on these vertical lines and a *contour line* drawn through the points so marked

This is very simple to apply Suppose in fig 5,420, ABCD, represent the sides of a building to be constructed and it be required to lay out these lines to the dimensions given. Substitute the values given in equation (1) thus

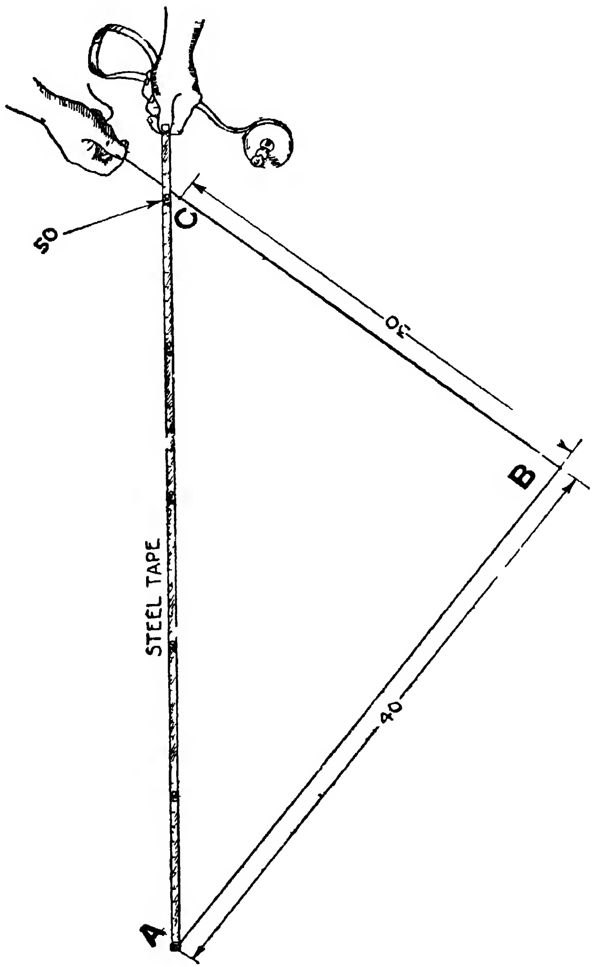


Fig. 5 418 —Method of laying out lines for a rectangular building by aid of diagonals *This is virtually* the process of constructing a large layout square using lines and steel tape in place of boards

$$AC = \sqrt{30^2 + 40^2} = \sqrt{900 + 1600} = \sqrt{2500} = 50$$

To lay out the rectangle of fig 5,420, first locate with stake pins the 40 ft line AB

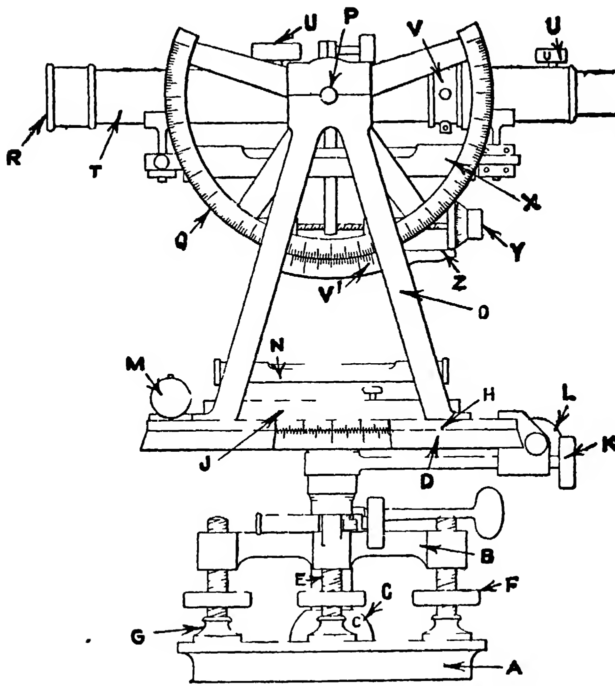


FIG 5 419 —Transit *The parts are* A lower plate B upper plate C central dome, D, divided limb E spindle F foot screws G foot screw cup H vernier plate J compass circle K clamp screw vernier plate to divided limb L tangent screw M and N spirit levels O standards or supports P horizontal shaft Q vertical arc R objective S, ocular, T, telescope U racks and pinions V adjustable cross hair ring *v* divided limb vernier *v'*, vertical arc vernier X spirit level Y gradienter Z scaled index These parts are described in detail in the main text

Attach to B, the line for the second side and measure off on this line the distance BC, or 30 feet, the point C, being indicated by a knot This distance must be accurately measured with the line in the same tension as when later adjusted

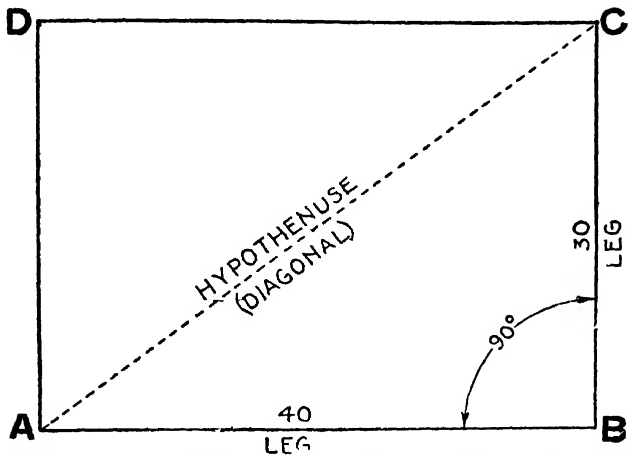


Fig. 5,420 —Diagram illustrating how to find the length of the diagonal in laying out lines of a rectangular building by the method of diagonals

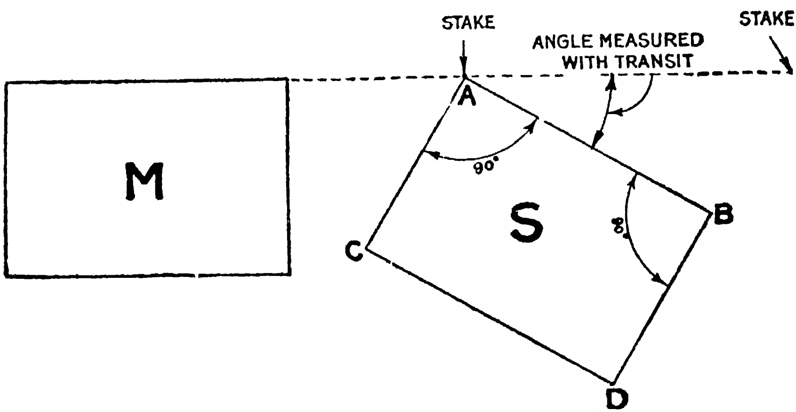


Fig. 5,421 —Method of laying out a new building S at a given angle with an old building M After the corner and the direction of one wall are determined, a right angle may be laid off (if the building be rectangular) thus locating two of the sides, as AB and AC The length of the side AB is now measured, locating the corner B The transit is set up at B, and the line BD, laid off at right angles to AB AC, and BD, are then laid off the proper length, and thus the four corners of the building located If the building had not been rectangular the proper angles could have been laid off instead of right angles It is often desirable to make a block plan or map of the grounds and buildings of a plant

With end of steel tape fastened to stake pin A, adjust positions of the tape and line BC, until the 50 foot division on the tape coincides with point C, on the line, then will ABC, be a right angle and the point C properly located.

Proceeding in a similar manner, lines for the other two sides of the rectangle are laid out. After thus obtaining positions for the corner stake pins erect batter boards and permanent lines as in fig. 5,410.

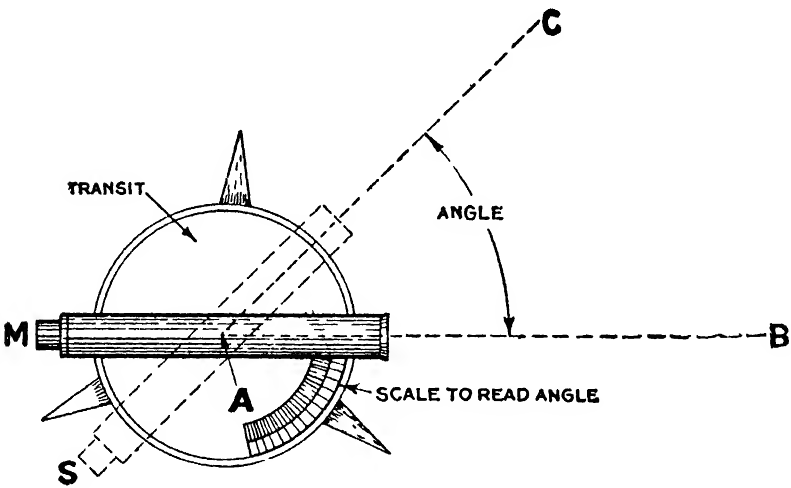


FIG. 5,422 —General principle of transit work *The transit is placed over the apex A, of the angle BAC, to be measured Telescope is sighted to stake B (position M), and reading taken; then turned horizontally and sighted to stake C (dotted position S), and reading taken The difference of these readings gives the angle* BAC Obviously C, may be located so that line AC, will make a given angle with AB, by turning telescope until the scale reads the desired angle The stake is then driven in the line of sight.

Points on Laying Out.—In most localities it is customary for the carpenter to be present and to assist the mason in laying out the foundations. Upon ordinary residence work a surveyor is employed to locate lot lines.

Once these lines are located, the builder is able to locate the building lines by measurement.

A properly prepared set of plans will show both the present lay of the ground upon which the building is to be erected, and the new grade line which is to be established after the building is completed.

The most convenient method of determining old grade lines and of establishing new ones is by means of the transit, or

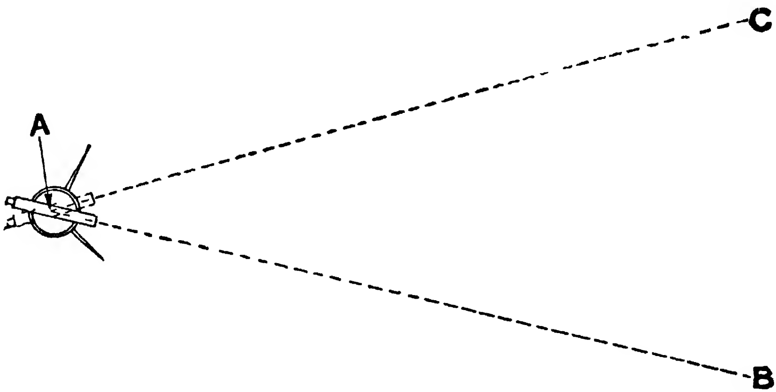


FIG. 5,423 – Method of measuring a horizontal angle. ***To measure an angle*** as between the lines AB and AC, set up and level the instrument at A, as already described and clamp one of the verniers at the zero mark on the circle. Turn the telescope upon the target at B, and clamp the limb. Unclamp the vernier plate, and turn the telescope upon the other target at C. Read the vernier which had been set at zero and the reading will be the horizontal angle through which the telescope turned from B to C. It is not necessary to set the vernier at zero before pointing at the first target. The result will be the same if the vernier be read when pointed at the first target, and then again, when pointed at the second. The difference between the two readings will be the angle required. Care must be taken in this method to note if the vernier pass the 180 degree mark and, if so, to make the proper calculations. For simple work, where there are but few angles to be measured, it is less confusing to set the vernier at zero each time, especially for those not experienced in the work.

the Y level with the rod. Both instruments work on the same principle in grade work. As a rule the mason has his own Y level and uses it freely as the wall is constructed, especially where levels are to be maintained as the layers of material are placed.

In locating the earth grade about a building, stakes are driven into the ground at frequent intervals and the amount of "fill" indicated thereon.

Grade levels are usually established after the builders have finished, except that the mason will have the grade indicated for him where the wall above the grade is to be differently finished from that below. When a Y level is not available, a 12 or 14 ft. straight edge with a common carpenter's level may be used, using stakes to define the level.

CHAPTER 97

Foundations

According to the Building Code, the term *foundation* includes all walls, piers or other supports below grade or curb levels. The proper construction of any foundation depends entirely upon conditions and the architect's plans, presuming, of course, that their plans are properly prepared. There is a multiplicity of ways in which foundations are made and various materials are used, such as wood, concrete, brick, stone, etc. The particular kind of foundation best suited for a building depends upon the nature of the earth and other conditions

It is not often that the builder must determine sizes as in most instances the plans come to him with all sizes detailed and marked, but, in the event of his coming upon conditions not discovered by the architect he should be qualified to speedily discern how to overcome them and proceed with the work in a proper manner.

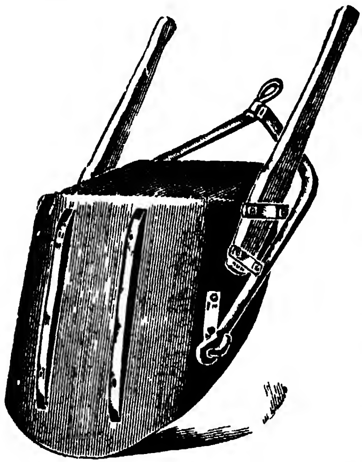
Timber Post Foundations—The wooden post or pile is the simplest and cheapest form of foundation for light frame building, tool houses, shops, bunk houses, bungalows and such like, on account of its handliness, ease of obtaining, rapidity of handling and placing and economy of time and material.

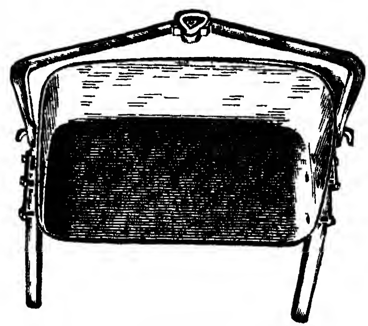
Earth Excavation.—In every building specification made by a competent architect or engineer the details of the excavation

form an important part. There is hardly a class of building construction into which excavation of earth or rock does not enter to some extent.

The following data on earth excavation will be found useful.

One excavator using pick and spade, will keep busy two shovellers and two barrow wheelers in compact earth, but only one of each on ordinary clay.





FIGS 5,424 and 5,425—Two forms of scraper These are like steel scoops, shovels or spoons, used for moving loosened earth or other material a pair of horses are harnessed to the bail or cross piece by means of whiffle trees and the scraper is then drawn over the ground scraping up the surface like a spoon The tool has a capacity ranging from three to seven cubic feet and is guided by the driver who dumps the contents at the required spot by manipulation of the handles and steering the horses so as to tip the scraper

A shoveller will throw each shovel full of earth six to ten feet horizontally, or four to five feet vertically.

In an eight hour day a good excavator will dig and throw into a barrow six to eight cubic yards of common ground, about five cubic yards of firm clay or compact gravel, or from two and one half to four cubic yards of hard ground where the pick has to be employed One excavator to each six feet of face of cutting is as close as is desirable

Wheel barrows holding $1/10$ cubic yard. are the most economical means

of transport where the distance does not exceed 100 yards. Barrow runs should be provided, as they increase the capacity of the wheelers by at least 50 per cent. These consist of 12″ × 3″ planks, mounted on box horses where it is desired to give an inclination. The gradient should not be steeper than one in twelve, unless assisting gear, such as hauling ropes, be provided. Efforts should be made to keep the slope down to one in thirty. A barrow run is reckoned as about twenty-five yards each foot of rise being estimated as equal to two or three yards extra run.

Tip carts drawn by one horse are much used in transporting earth. but with them as with barrows it is more economical to provide good temporary ways, as the hauling power will be doubled thereby. Assuming good ways, a cart can hold ¾ cubic yard of earth, or say 1 ton.

In dealing with the removal of earth from long and narrow trenches, as in the case of foundations, most of the foregoing methods cannot be used.

A rectangular bucket, narrow in comparison with its length, is designed for this special service, and is intended to be worked by a crane or hoisting engine.

A method, modified from a mine prospector's device, is as follows: A trestle is erected astride the trench, having a runway *rising* slightly to the dump. A four wheeled carriage rests on this runway, and is locked in position by a catch over the trench; from this carriage is suspended the pulley for the bucket rope. A horse travelling horizontally pulls the bucket vertically, as soon as it is fully hoisted it disengages the carriage, and the horse pulls carriage and all to the dump. As soon as the bucket or skip is emptied, and the horse starts to return, the carriage runs back along the runway by its own weight, and becoming automatically locked again, the bucket descends into the trench once more.

If a portable railway can be used, it is also advantageous in working on a slope, to have the team of horses travel on the level, pulling at a rope led around pulleys and fairleads.

Shoring.—The term *shore*, in carpentry, means an upright or slanting strut or brace, the upper end of which presses against the object supported. Shoring or the insertion of such braces or struts is frequently resorted to in excavating foundations; this means placing timber struts obliquely against the walls of a building to support it, should it be in danger of falling, or whenever alterations are being made to its base. Naturally, if

an excavation be carried close to the walls of an existing structure, the pressure will tend to force the footings sidewise, and a collapse is threatened

Rectangular holes are cut in the upper part of the wall to be supported, in which are placed timber *needles* usually six inches square and a foot long, projecting seven or eight inches. On

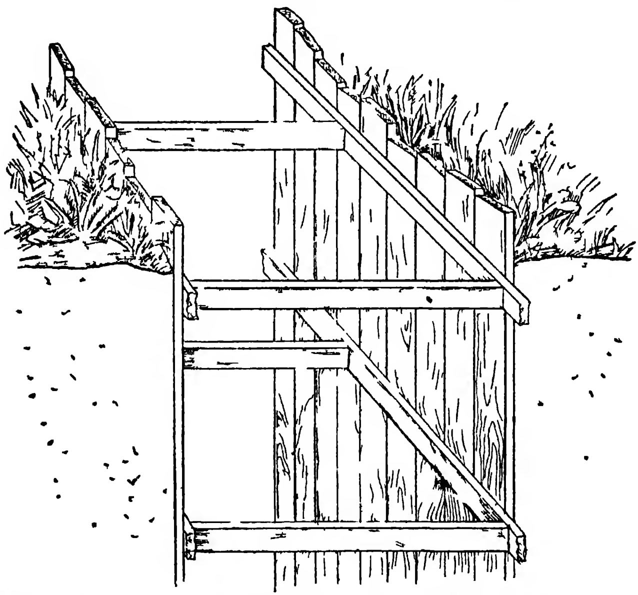


FIG. 5,426.—Ordinary shoring. ***In construction*** put planks behind the frame and drive them down with a wooden beetle as far as possible. Always dig on the outside line of the hole first, say about two feet deeper than the center; this gives a chance to lower the frame and planks and makes the work easier. As in many cases where the soil is very soft and water appears at no great depth, have a place kept lower at all times to put a pump in or bale out.

these needles is placed vertically a stout plank, its length depending upon the height of the building. Shores are arranged in tiers of three, abutting on one end upon a footing block of wood, and at the other upon the upper, middle and lower

needles through each plant. A customary size for these struts or shores is 12″×6″.

A cleat is usually nailed to the plank on the upper side of each needle to reinforce it, and one inch planks are nailed to the sides of each tier of shores to hold them together.

In deep excavations an important point is to have proper shoring; have the planking and timbers so placed that it will

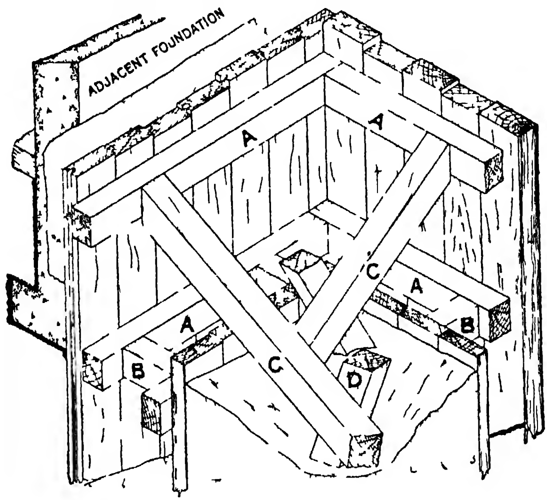


FIG. 5,427.—Detail of shor[illegible] of construction when an excavation is to extend below an adjacent foundation or one near enough that it might be endangered by it. When the excavation is made as deep as can be safely made planks of a suitable size are sharpened on the bottom end and driven down behind stringers A A A A when required to be tight they are tongued and grooved. Braces CC are spiked to the stringers and to post anchors D, that are driven securely into the earth. When an inside row of planking is used to form trench braces B hold them a uniform distance apart. They are removed as the foundation rises.

prevent a cave in. Fig. 5,426 shows ordinary shoring consisting of a framework and planks.

Underpinning.—This comprises a solid structure introduced temporarily or otherwise beneath the foundations of an existing

building to support them in case of alteration or excavation beneath the footings.

A favorite method of underpinning is to build piers in pairs, one each side of the threatened wall, to the desired height from solid ground. The wall is pierced for rectangular wooden beams, termed "needles," which rest with one end on each pier of a pair. Wedges being driven in under the needles, the weight of the wall is transferred from the footings to the piers.

Footings.—The term *footing* means *the lower and expanded*

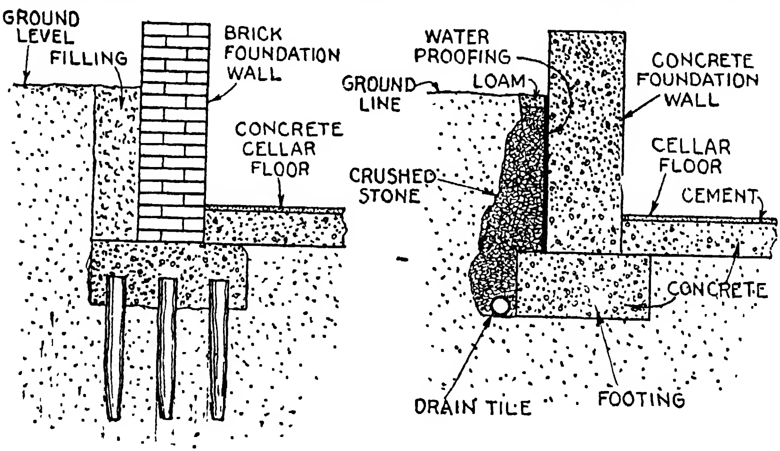


Fig. 5,428 —Foundation construction showing footing of piling embeded in concrete cap, and brick foundation wall, the cellar being provided with a concrete floor.

Fig. 5,429.—Foundation construction of all concrete showing method of water proofing with crushed stone and drain pipe.

portion of a foundation which rests on the excavated surface. It is made wider than the foundation wall so as to reduce the pressure (per unit area of surface) to be supported by the excavated surface and thus reduce or prevent settling. The extent of this widening of the footing will depend upon the nature of the excavation or surface upon which the footing rests and the weight coming on the footing.

To illustrate this, assume that fig 5,430 represents the plan of a proposed building and that the materials of the earth under the footings are composed of different strata as rock, clay and uncertain sand, a condition not unusual in modern work, and that these materials are located as represented by the wavy lines

The capacities of the materials being different, it must be understood that they must be differently treated, so as to be when treated, all of equal capacity For instance, rock is a stable material by itself capable of sus-

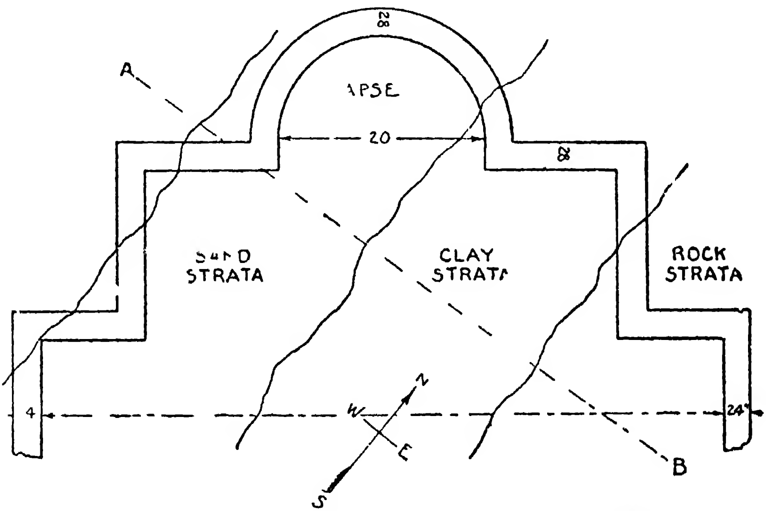


Fig 5,430 —Foundation plan of part of a church showing various materials, sometimes found in excavating

taining a weight of 200 tons to the square foot and fully fit The other materials on which the foundation is to rest are compressible and unfit, so that they must be treated artificially to bring them up to the standard of the rock

In preparing such a bottom begin at the sand portion, and make it fit by excavating to the specified depth or even past that to a good solid strata deep enough and dense enough to carry the weight superimposed, but if there be a possibility of the sand layer resting on the sloping top surface of the dipping rock, then he must dig down to the rock and level it off for a bearing Should, however, the sand be retained within a hollow spot or

basin in the rock, then the sand will be safe enough to build on, but this must be ascertained by test holes

The same directions apply to the clay stratum, which varies sometimes more than sand, especially when there has been a deposit of water, showing a blue spongy material in the composition, which constitutes a compressible turf, in fact, clay varies more than sand, and consequently it must be more closely scanned to ascertain its nature and capacity

Concerning the material for the footing courses on bottoms of this assorted nature, concrete is considered the most reliable

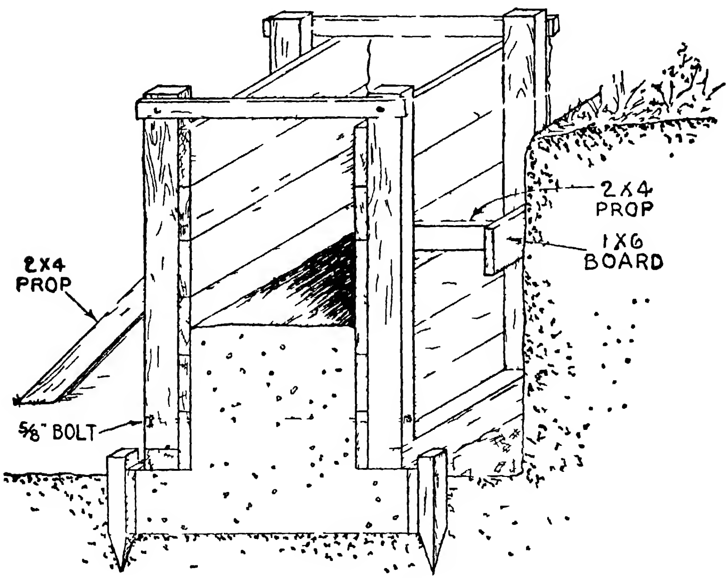


FIG 5 431 —Form for concrete foundation wall and footing Such forms should be made of semi-seasoned wood as when thoroughly seasoned the wood will warp badly when the wet concrete is placed Spruce Norway pine etc are better woods to use than hard or Georgia pine For ordinary foundation work 1 inch boards may be used The studs may be assisted materially in holding the forms in position by wires placed on studs And by props placed against the dirt wall of the excavation *In filling* use a wet mix lay a 4 inch layer and then spade or work it well into place The smoothness of the resulting faces is increased by an additional spading of the mixture away from the form A good spading tool is made by straightening out an ordinary garden hoe Forms should be allowed to remain until the concrete will resist indentation with the thumb upon ordinary walls

Sometimes the excavated surface is rendered fit for supporting the foundation by driving down a number of piles, the foundation being in fact carried by these piles Many fixed standards are given for footings and foundations

The New York Building Code requires all footings to extend in ordinary concrete or bottom stone six inches outside the face of all walls or piers, or the spread of the footing to be 12 inches

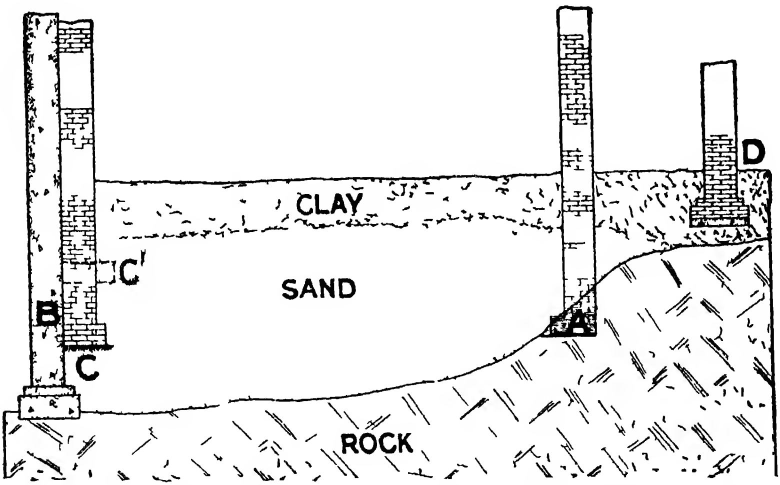


FIG 5 432 Section of foundation showing at A a rock condition below a sand stratum sloping at a point where a foundation base must be placed and how it is levelled for it to avert any possible danger of its creating a pressure against the resting sand by which it might yield upward where not under compression other than its own weight thus allowing base to slip and cause disaster If it is to be placed against another wall as at B it will be safe to lay the base at any depth below front in the sand as at CC The sand cannot yield or be displaced unless voids are created At D the rock bed is quite level and the clay rests upon it, here the base of foundation may start even without going to rock bottom and be perfectly safe

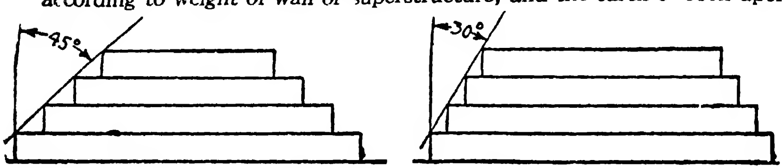
wider than the wall or pier which it will carry, and not less than 8 or 12 inches deep, which is in accordance with the rule followed by architects

Brick footings on rock or concrete may be used if properly spread and

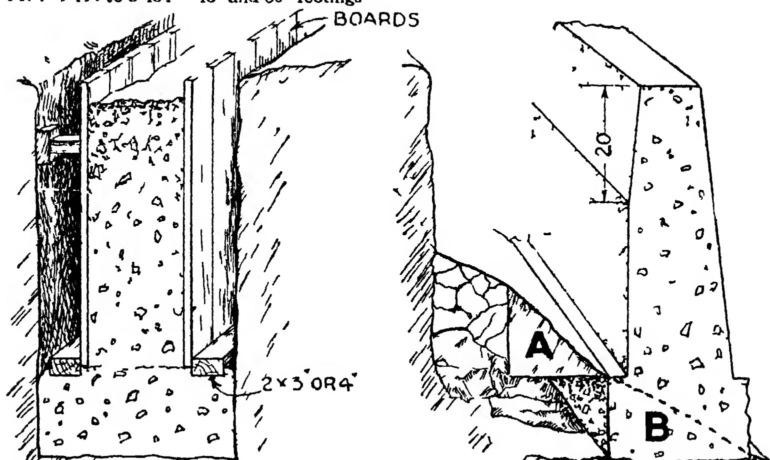
bonded but a given proportion set to a recognized and fixed angle will be necessary

Fig 5 433 shows a stepped up footing of brickwork with the stepping set to an angle of 45 degrees, which is easily obtained by setting back two inches, on the square of the thickness of each brick, until the thickness of the pier or wall is reached Similarly in fig 5 434 the foundation is set back or splayed to an angle of 60 degrees (with the horizontal) with one inch steppings on each course

Some prescribed angle should always be adhered to calculated or course according to weight of wall or superstructure, and the earth or rock upon



FIGS 5 433 to 5 434 45° and 60° footings



FIGS 5 435 and 5 436 —Cement base or footing surmounted by a cement wall erected in a trench where there is to be no excavation below grade but to a depth sufficient to allow for excavating at any future time without endangering wall After the trench is leveled concrete is spread to a depth required for the weight of superstructure Two timbers equidistant from the center are tamped into the base The next day the remainder of the work may be done from the surface The concrete spreads bottom ends of boards to place All that remains then is to plumb and wedge them Fig 5 436 shows an entire different condition here the wall is erected on a slope the rock formation is cut away at B for base Before filling against wall wherever the pitch is near the wall as at A it cut away so that the thrust of fill will be perpendicular rather than outward

which it starts. Also a very important matter is to preserve the bonds always with a two-inch overlap.

Every pier or brick buttress must have its foundation footing placed at right angles to the axis or center line of its axis, be it plumb, racking, or battered, so that the thrust on the base shall be directly on the axis line.

Finally, as a general rule, all foundations and footings should never be less than one-third wider than the wall above.

Filling.—After foundation walls have been completed, the

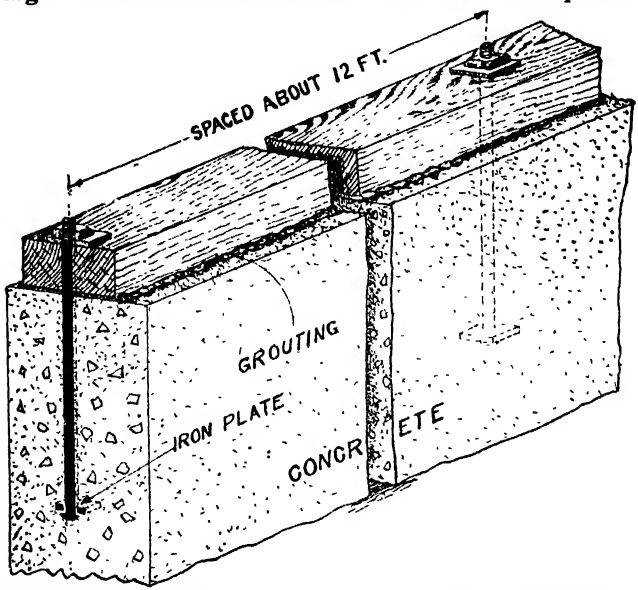
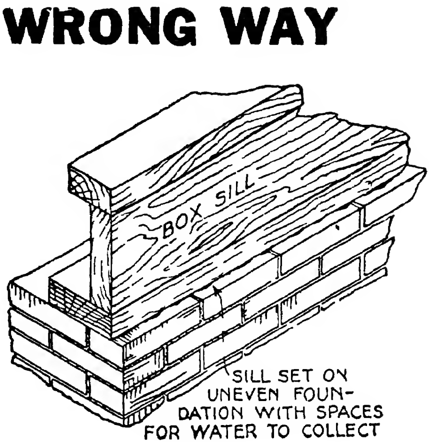
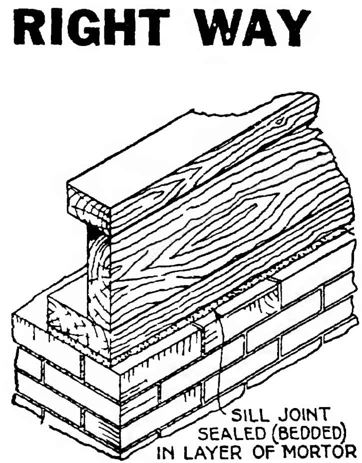


FIG. 5,437.—Concrete foundation wall showing approved method of anchoring sill by anchor bolts and seal of grout which prevent entrance of moisture under sill, thus protecting the latter from decay.

earth previously excavated must be filled in against the outer sides up to the level of the ground.

Many new walls have been sprung, sometimes so badly as to have to be rebuilt, on account of improper method of filling.





FIGS 5 438 and 5 439 —Wrong and right way to set sills especially built up sills The joint between the bottom of the sill and top of foundation should be thoroughly ceiled to prevent entrance of moisture or water which will quickly rot the sill Moreover, when the joint is not ceiled cold air will come in through the cracks, also insects

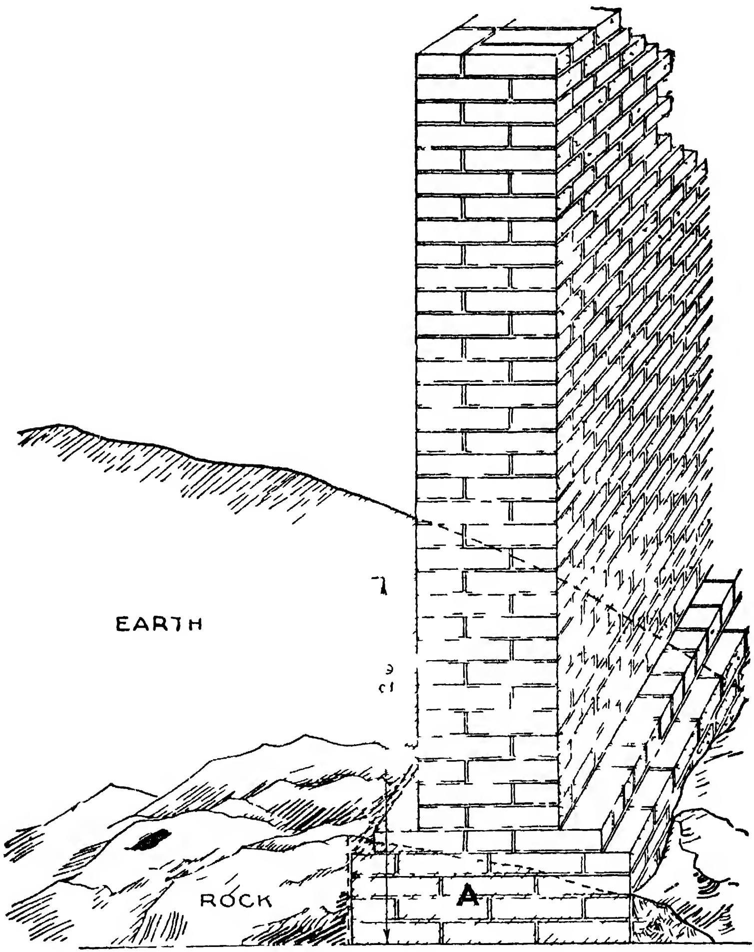


FIG. 5,410 —Rock foundation showing need of cutting a level **A**, on a hill side in order to get a level and secure footing safe below frost line

Sometimes heavy walls are thrown down by filling in with earth between the wall and the inclined bank of the excavation, causing a sliding pressure against the wall as the fill and weight increases. Sometimes the slide is accelerated with much water settling through it before finally settled, which takes much longer than the seasoning of the mortar in wall.

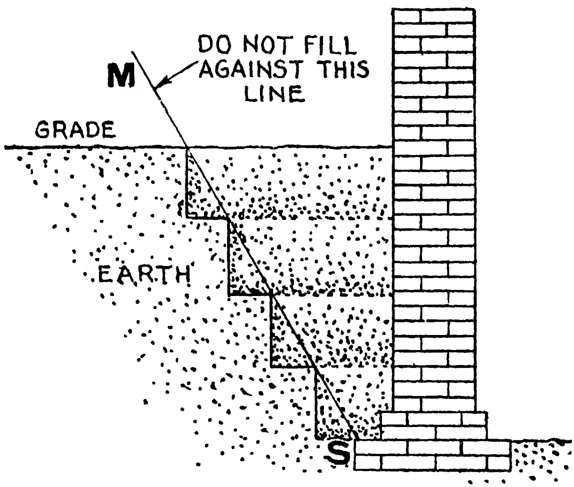


FIG. 5,441.—Correct method of filling against wall. Evidently the fill is partly supported by the series of steps rather than wedged against the wall when the side of the excavation slopes outward as indicated by the line **MS**.

The simple remedy is to level the bottom and square the sides in step courses as the fill is made, as shown in fig. 5,441; this prevents the wedging action which would be present were the side of the excavation sloping as indicated by the line MS.

CHAPTER 97A

Plasters

By definition, plaster consists of a pasty composition which hardens on drying, and is used for coating of walls, ceilings and partitions.

Ordinary plaster is made by mixing sand and water with *gypsum plaster*, *quicklime*, or *hydrated lime*. Hair or fiber is sometimes added to act as a binder.

Gypsum Plasters.– Gypsum plaster (also called cement plaster) is obtained from the mineral gypsum (gypsum rock). The gypsum rock used in the manufacture of gypsum is hydrated calcium sulphate, containing approximately 20% of chemically combined water. In the calcination process most of this water is driven off, producing *plaster of Paris* which is the base of all gypsum plaster. On the remixing with water on the job, the material takes back the water driven off in calcination and crystallizes or sets to the original gypsum rock.

Gypsum products are generally used as a base plaster in most plastering work, also as a soil dressing, and for numerous other purposes. The finished product is usually shipped out from the mills in 100 lb. paper bags; and some specialty products in 250 lb. barrels.

Lime Plasters.—These are obtained by the calcining of limestone, shells or other forms of calcium carbonate and are usually employed in plaster finishing coats. Depending upon its quality

it is also called *quicklime, burnt lime, caustic lime, lime putty,* etc. Chemically pure lime is calcium oxide, carbon dioxide being driven off in the calcining process, but commercial limes commonly contain impurities, as magnesia, alumina, iron oxides and silica.

High calcium limes containing less than about five per cent of magnesia, are called fat, strong or rich limes; *magnesium limes* containing a greater amount of magnesia, are called *lean, weak* or *poor*, because they do not slake readily; *lump lime* is *quicklime* as it comes from the kilns.

There are two chemical classes of quicklimes; *high calcium* and *dolomitic*. Both must be slaked at a temperature near the boiling point. The high-calcium lime combines with the water almost instantly and gives off its heat very rapidly; while the dolomitic is rather slow to combine with the water, but when it does, generates its heat very rapidly also.

The high-calcium lime requires fairly fast agitation, as it is combined with the water, while most dolomitic limes do not require any agitation until they begin to generate their heat, and then about the same agitation as the high-calcium. Some high-calcium limes, especially those burned in rotary kilns, combine with the water so fast that a volume of lime must be dumped into the required volume of water at once and must then be agitated very rapidly to prevent "balling up" or "gumming up" while being slaked.

The dolomitic limes when chemically pure, contains 45.5% magnesium carbonate, 54.5% calcium carbonate. It is the magnesium carbonate, when properly burned which gives the plasticity and easy slip or working qualities of a building lime.

One of the important steps in the production of good lime is in the proper burning of magnesium carbonate. As the calcium and magnesium carbonate require widely different temperatures to change them into oxides by burning, it requires very close regulation of heat.

To obtain the necessary heat regulation most modern lime plants have installed special heat regulating apparatus which controls the burning automatically to prevent over burning

Similarly the hydration process is also closely and automatically controlled by special equipment Lime as it comes from the kiln exists as calcium and magnesium oxides A definite percentage of water is added which combines chemically with the calcium oxide but *not* with the magnesium oxide The lime is then grounded and sacked in special paper bags usually containing 100 lbs each

VARIOUS TYPES OF PLASTERS AND THEIR USE

In view of the numerous local or descriptive names for the same type of plaster and widely varying market practices, it is felt that the following classification of plaster as to *ames* and *uses* will be of assistance

Base Coat Plasters

Among the various types of base coat plasters are the following *Cement plasters* (fibered and unfibered), *sanded plaster*, *wood fiber plaster*, *sanded wood fiber plaster*, *concrete bonding plaster*, etc

Cement Plasters. These plasters constitute the bulk of tonnage of all types of *gypsum* plasters used The term relates to all *neat* (the term *neat* designating a plaster containing no sand or other aggregate added at mill) plasters either with or without hair or sisal fiber (Wood fiber plaster is never classified as a cement plaster) Cement plaster is also known by the following names in many markets

1. Hardwall plaster
2. Patent plaster
3 Neat plaster
4 Compound plaster.
5 Paristone plaster
6 Base coat plaster

Fibered and Unfibered Cement Plaster.—These are termed as: *hair fibered plaster and unfibered plaster.* Hair fibered plaster may contain either hair or sisal fiber. Sisal in plaster is generally recommended as being more satisfactory than hair in plaster. Unfibered plaster designates only cement plaster containing no fiber.

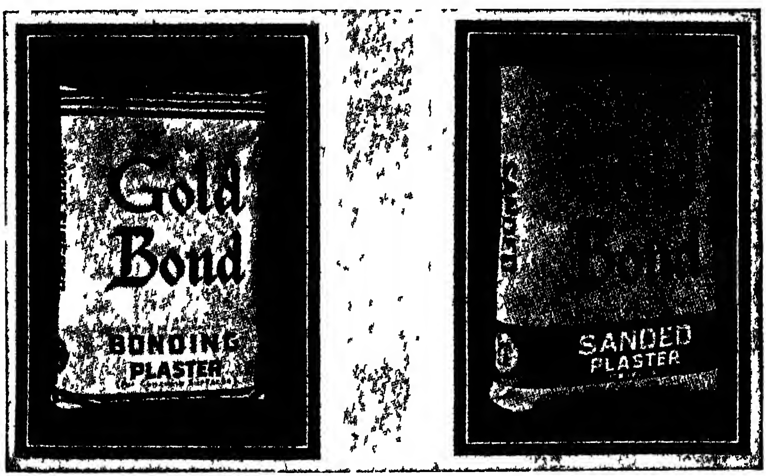
Figs. 1 and 2.—Showing two types of fibered plaster packed in special 100 lbs. paper containers. *Courtesy National Gypsum Company*

Sanded Plaster.— This material is the same as cement plaster, except that a properly graded sand has been added at the mill in the proper amount for best plastering results. It has been called by many names listed under *cement plaster* except with the term *sanded* used in addition.

Wood Fiber Plaster.—This type of plaster contains a finely shredded wood fiber and is made primarily for use with addition of water only on the job. In some cases, however, a small

amount of sand (never over one part by weight) is added on the job. In some markets this material is known as *pulp plaster*.

Sanded Wood Fiber Plaster.—This plaster is of the same general order as wood fiber plaster except a small amount of specially graded fine sand is added. Its uses are the same as with *wood fiber plaster* and is used in certain markets where the trade prefers a sanded wood fiber.



Figs. 3 and 4.—Illustrating typical plaster bags containing bonding plaster for concrete surfaces and sanded plaster, each of 100 lbs. net weight. *Courtesy National Gypsum Company.*

Concrete Bonding Plaster.—This is especially formulated *wood fiber plaster* to provide maximum bond to interior concrete surfaces. Ordinary gypsum or lime plaster does not bond properly to concrete surfaces. Water only is added in mixing on the job.

Bond Plaster.—This material is the same as concrete bonding plaster.

Uses for Base Coat Plasters

Cement Plaster.—This material is generally used for plaster work where good plaster sand is easily available and it is economically advisable to mix sand on the job rather than to use mill-mixed material. Cement plaster is formulated for use with sand in amounts covered *in directions for use* and should never be used *neat*, that is, without addition of sand.

Sanded Plaster.—This material is being used largely where good plastering sand is not easily available, where absolute exactness of proportioning of amount of sand is required, where facilities for mixing are limited or where job is not large enough to justify trouble of mixing sand on the job. Sanded plaster is used solely with addition of water on the job.

Wood Fiber Plaster.—This material is used to a large extent for *patch jobs*, for work where an extremely hard wall is wanted, where base plaster is to be trowel finished, where sand is not easily available, etc.

Finish Plaster

These as the name implies are used to obtain the finish plastering coat. There should be at least a seven day interval between application of the brown coat and finish coat.

Plasterers in most sections of the country are accustomed to use a *slow set gauging* plaster which is properly retarded at the mill for use with *lime putty* for a *gypsum-lime putty trowel finish*. In some sections of the country a *quick set gauging* plaster is used with lime putty in which case it is usually necessary to add a retarder to obtain the desired setting time. Small

amounts of commercial retarder as supplied by the dealer, or small amounts of either unfibered plaster or screened fibered plaster are ordinarily used.

Gauging Plaster. – This is a specially ground calcined gypsum which may be either pure white or grey in color and quick or slow in set. Other names used to designate this material are as follows:

1. Plaster of Paris.
2. Calcine.
3. Finish plaster.
4. White plaster (for pure white material only)
5. Stucco.

Uses for Gauging Plaster. This material is always used in connection with lime putty finish and the essential ingredients which provides an initial set and prevents the slow setting lime from shrinking, checking and peeling before the set of lime itself takes place. The failure to use the proper amount of *gauging plaster* is the cause of most failures of lime putty finish jobs. The type of *gauging* used depends upon trade practices in each locality. The following types of material are used:

1. White gauging (quick set).
2. White gauging (slow set).
3. Grey gauging (quick set).
4. Grey gauging (slow set).

Moulding Plaster.- This is made of selected rock and specially prepared for requirements of its use. This is also sometimes called *plaster of Paris*. It is used for plaster moulds, ornamental plaster work of all kinds and can be used as a substitute for quick set *gauging plaster*. It is generally made as a pure white plaster, but in a few localities *grey moulding* is used for special purposes.

Prepared Trowel Finishes.— These plasters are gypsum finish plasters manufactured to avoid the problems involved in use of ordinary lime putty finish. They contain no lime, but various ingredients are added to produce exceptionally easy working and spreading qualities. Water only is added on the job. They are also known as

(a) Smooth trowel finishes, and
(b) Gypsum trowel finishes.

Figs. 5 and 6. Illustrating typical hydrated lime plaster packed in heavy paper containers, each having a net weight of 50 lbs. *Courtesy National Gypsum Company*

Use of Prepared Trowel Finishes. These finishes are available as a substitute for lime putty finish whenever desired. They have replaced lime putty finish in some markets. They have the advantage of perfect bond to base, quick setting and freedom from danger of lime burn in decoration. These finishes can be safely decorated in any manner as soon as dry. They are available in both grey and white.

Sand Float Finishes.—These are also prepared gypsum finish with addition of fine sand, for use over gypsum base coat. They are used in markets where the semi-rough surface or a sand float finish is desired. As the name implies these materials are *floated*--not trowel finished. They are furnished in both grey and white.

Keene's Cement. - This is an exceptionally dense gypsum finish fundamentally different from all other types of gypsum plasters and are made by various plaster manufacturers. This type of cement is made in several different styles with various setting times and with the grind ranging from coarse to superfine.

Uses of Keene's Cement. This material is used wherever extremely dense walls are required, such as imitation-like finishes in bathrooms and kitchens or any place where the walls will be subjected to unusual abuse. Also used as a finish coat instead of lime putty, for castings and running moulds, backing up artificial marble, also for the facing of artificial marble and for numerous ornamental plastering effects.

APPLICATION AND MIXING OF PLASTER

The plastering process consists generally of applying coats of specially prepared mortar to a wood, metal or other lath base to form interior of wall surfaces of buildings.

The lath base for plaster work are termed according to the material as:

1. Gypsum lath.
2. Wood lath.
3. Metal lath, etc.

Other lathing backgrounds may be *masonry surfaces*, various types of wire meshed materials and wood, with and without paper backgrounds, and other special patented lathing materials are on the market.

Plasters are usually applied in three coats which are termed in order of application as follows:

1. The scratch coat.
2. The second or brown coat.
3. The finish or set coat.

The Scratch Coat.—This coat should be made approximately $3/8$ in. thick measured from the face of the backing and carried to the full length of the wall or the natural breaking points like doors or windows. Before the scratch coat begins to harden, however, it should be cross-scratched to provide a mechanical key for the second or brown coat.

The Brown Coat. The brown coat should be of approximately the same thickness as that of the scratch coat. Before starting to apply the brown coat, dampen the surface of the scratch coat evenly by means of a fog spray to obtain *uniform suction*. This coat may be applied in two thin coats, one immediately following the other. Such a method may prove helpful in applying sufficient pressure to insure a proper bond with the base coat.

Bring the brown coat to a true even surface, then roughen with a wood float or cross-scratch it lightly to provide a bond for the finish coat. Damp-cure the brown coat for at least two days, then allow it to dry.

The Finish Coat. The brown coat should be dampened for at least two days before application of the finish coat. Begin

moistening as soon as the brown coat has hardened sufficiently not to be injured, applying the water in a fine fog spray. Avoid soaking the wall, but give it as much water as will readily be absorbed. The methods used to obtain various textures is given on pages 862-17 to 862-19.

Plastering Materials and Mixing. All materials used in plastering shall be stored in a dry place above the ground and shall be handled in such a way as to prevent deterioration or intrusion of foreign matter into the plaster.

Lime, gypsum and cement shall be delivered and stored in original packages of the manufacturer. Any materials in containers showing water marks or which have been damaged or materials that have deteriorated shall be immediately removed from the premises.

Mixing boxes for base coats shall be clean and tight, approximately 3½x7 ft. and 12 in. deep and 2½x4½ ft.x10 in. deep for finish coats and raised 1 in. at one end. Clean mixing boxes after each gauging.

Machine mixing shall be permitted in machines made for this purpose if they be cleaned after mixing and kept free of plaster from previous gaugings. Tools shall be kept clean and shall not be rinsed in gauging water.

No more material shall be mixed than can be applied in one hour. Do not mix one gauging with another. Plaster shall not be retempered after it has commenced to set.

NOTE: Clean water and proper mixing following the direction of the manufacturer are of extreme importance to good work. Plaster shall be kept from freezing for 24 hours after application and no finish shall be applied to base which is frozen

In hot, dry weather, all openings shall be enclosed with muslin screens or windows kept closed to prevent plaster from drying before it has set; after that, windows shall be opened to permit wall to dry quickly.

Sand for base coats shall be sharp, clean and free from saline, alkaline, organic or other impurities. It shall be graded from fine to coarse in conformance with the Standard Specifications for Plastering Sand of the American Society for Testing Materials. Pass through six-mesh screen.

Sand for finish coats shall all pass a No. 12 screen and shall be white, hard, durable grains free from soluble salts or injurious amounts of organic matter.

Scratch and Brown Coat

On Gypsum Lath.—First or scratch coat shall be one part fibered plaster to not more than two parts, by weight of clean, dry sand. The lath shall not be wetted before plaster is applied. The first coat shall be thoroughly applied and the plaster worked well into the joints and the surface shall be scratched or scored to provide a bond for the second coat.

Second or Brown Coat. This coat shall consist of one part plaster, fibered or unfibered, to not more than three parts, by weight of clean, dry sand. Second coat shall be applied when the first coat is set firm and hard, but before it is dry. Second coat shall be straightened, keeping back sufficiently from the grounds to allow for finishing coat and the surface shall be broomed or otherwise roughened to receive the finishing coat.

On Wood Lath.--Scratch coat shall consist of one part of fibered plaster to two parts by weight of clean, dry sand.

Wood lath shall be thoroughly wetted 12 to 24 hours before plastering is started. First coat shall be applied with sufficient pressure to fill all spaces between lath and obtain good key, leaving a light coat over the lath, and the surface shall be scratched or scored to provide a bond for the second coat.

Second or Brown Coat. Second coat shall consist of one part plaster, fibered or unfibered, to not more than three parts by weight of clean, dry sand. Second coat shall be applied as soon as scratch coat is set hard and at least ¾ dry, to a true and even surface. The surface shall be broomed or otherwise roughened to provide a bond for the second coat.

On Wire or Metal Lath. Scratch coat shall consist of one part of fibered plaster to not more than two parts, by weight, of clean, dry sand. First coat shall be applied with sufficient pressure to fill all meshes and obtain good key, leaving a light coat of plaster over the lath, and the surface shall be scratched or scored to provide a bond for the second coat.

Second or Brown Coat. This shall consist of one part plaster, fibered or unfibered, to not more than three parts, by weight, of clean, dry sand. Second coat shall be applied when the first coat is set firm and hard but before it is dry. Second coat shall be applied with strong pressure and straightened, keeping back sufficiently from the grounds to allow for finishing coat and the surface shall be broomed or otherwise roughened to receive the finishing coat.

On Masonry. Base coat shall be one part plaster, fibered or unfibered, to not more than three parts, by weight, of clean, dry sand. The surface of all unfurred brick, hollow tile or concrete block walls shall be wetted before plastering is begun when necessary to kill excessive suction. The plaster shall be applied to a thickness of ⅝ in. beyond the wall face in two oper-

ations. A thin layer shall first be applied with strong pressure to secure a good bond and shall be followed immediately with a second layer which shall be straightened to a true even plane. The surface shall be broomed or otherwise roughened to receive the finishing coat.

On Poured Concrete.—All concrete surfaces to be plastered shall be treated as follows: Remove with a wire brush all dust and loose particles. Grease, oil or efflorescence shall be washed off with a solution of one part of commercial muriatic acid to four parts of water, and the surface so treated, washed again with clean water.

Smooth and dense surfaces shall be hacked so as to provide a rough base or background for the plaster. Plastering upon smooth concrete surfaces, which are first covered with so-called waterproof paints or compounds, should not be allowed.

Base Coat.- Base coat shall consist of concrete bonding plaster used *neat* with only the addition of water. The base coat shall consist of one or more thin coats sufficient to straighten the walls and ceilings and shall be applied with great pressure to secure a good bond. If necessary to apply in two coats, double back with the same material. The plaster shall be not less than 1/8 in. nor more than 3/8 in. in thickness, exclusive of the finish coat. The surface of the base coat shall be broomed or otherwise roughened to receive the finishing coat.

Finishing Coat

A smooth white wall surface finish consists of one measure of gypsum gauging plaster to not more than *three measures* of *perfectly slaked fresh burned plasterer's lump lime putty* or standard *hydrated finishing lime putty* thoroughly and uniformly mixed

Finishing coat shall be applied when the base coat is set firm and hard and nearly dry. The surface of the base coat shall be sprinkled with water before the finish coat is applied when necessary to kill excessive suction.

All finishing coats throughout shall be applied and finished in the most workmanlike manner and shall be left plumb or level and true and even planed, free from trowel marks, blotches and without joints showing.

All finished plastering shall be protected from wind until set. In freezing weather, the contractor shall arrange with the general contractor that plastering shall be protected from frost until set hard and thoroughly dry.

In windy, hot, dry weather, openings should be screened but not closed. In all clear weather after plastering has set, doors and windows should be kept open as fully as possible.

Two-Coat Work

In some parts of the country and under certain conditions, plaster is applied to the thickness of the grounds in *two coats*. This *double-up*, *laid-off* or *laid-on* work as it is variously called in different localities, means the application of the scratch and brown coats together, or at least without permitting the usual time to lapse between them.

The scratch coat is applied in the way specified previously, but it is not permitted to harden, nor is its surface scratched. The application of the brown coat is started immediately after finishing the application of the scratch coat. This method is obviously cheaper than straight three-coat work, but certain precautions are essential to its successful use. The brown coat must be applied before the hardening of the scratch coat has progressed far enough to produce a glazed surface. The backing must be sufficient rigid of itself that it will not yield under

pressure of the trowel, and it will not sag under the weight of the combined coats. If it deflects to any appreciable extent, the keys which hold the scratch coat to it will probably be broken, and if it sags, it will be found extremely difficult to bring the brown coat out to a true plane surface.

For these reasons, doubled-up work shall not be applied to metal lath. Its use on wood is not recommended, particularly if the plaster is to be 7/8 in. thick. On masonry backings the use of doubled-up work is largely a question of application, if the plasterer succeeds in making the plaster stick and is able to form a true plane surface, the work will be satisfactory. This depends upon the thickness of the plaster and the nature of the backing. It is difficult to apply a doubled-up coat of a thickness greater than 5/8 in. The great suction exerted by gypsum tile makes the application of doubled-up work easy; on clay tile it is almost impossible.

On Gypsum Lath. -First or scratch coat shall be one part fibered plaster to not more than two parts, by weight, of dry, clean sand. The base boards shall not be wetted before plaster is applied. Base coats shall be applied in two operations- a thin layer of plaster shall first be spread under pressure over the boards and the plaster worked well into the joints. This shall be immediately followed with a second layer which shall be straightened to a true and even plane, keeping back sufficiently from the grounds to allow for the finishing coat. The surface shall be broomed or otherwise roughened to receive the finishing coat.

Finishing Coat.—For proper mixing and application of finishing coat in two-coat work see specifications for finishing coat, pages 862-14 and 862-15.

On Wood Lath.—First or scratch coat shall be one part of fibered plaster to not more than two parts, by weight, of dry,

clean sand. The wood lath shall be thoroughly wetted 12 to 24 hours before plastering is started. Base coat shall be applied in two operations—a thin layer of plaster shall first be applied with sufficient pressure to fill all spaces between lath and obtain a good key and shall be followed immediately with a second layer which shall be straightened to a true, even plane. The surface shall be broomed or otherwise roughened to receive the finishing coat.

Finishing Coat.—For proper mixing and application of finishing coat in two-coat work see specifications for finishing coat, pages 862-14 and 862-15.

COLORED TEXTURES

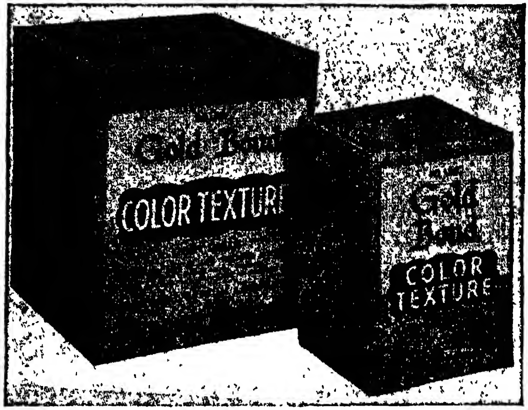
Various colored textures for interior walls are easily obtained from dealers in plaster products. In new construction, color texture is applied directly over the base plaster, eliminating the lime putty or white finish coat. Colored textures on interior walls have presently largely superseded the application of wallpapers, because of its permanent quality.

For actual beauty there is no comparison between textured rooms with their interesting designs and wallpaper with its monotonous patterns repeated over and over. In addition the cost of wallpaper or other decoration is also saved where colored wall textures are used.

Colors Used.- Color textures are usually manufactured in the following colors:

1. Ivory.
2. Light cream.
3. Light buff.
4. Light green.
5. Pink.
6. Light blue.
7. White.

Color texture is usually supplied in 10 and 25 lbs. cartons, with the color clearly printed on it.



FIGS 7 and 8 —Showing typical cartons containing color texture finishing plastic. This type of plaster is used mainly for interior walls and ceilings where special decorative effects are desired *Courtesy National Gypsum Company*

FIG. 9.—Showing typical *fine stipple* color texture plastic designs. The progressive steps to secure the finish are shown from left to right This texture has the effect of a sand finish. ***Procedure:*** Apply thin coat of color texture, with trowel or paint brush Smooth to uniform thickness with trowel. Texture with a fine stipple brush, cleaning brush occasionally to insure uniform texture Surface may be sand papered if desired to remove any sharp points *Courtesy National Gypsum Company*

Application of Colored Texture. The color texture is simply mixed with water, and applied with paint brush, or trowel in a thin coat, usually from 1/16 to 1/32 in. thick, then textured with stipple brush, rubber sponge, whisk broom or crumpled paper. A direction sheet usually accompanies each carton giving specific instructions for application over practically every type of surface. Typical designs of color textures are shown in figs. 9 and 10

Fig. 10. The same, another interesting plastic color texture design. The progressive steps to secure the finish are shown from left to right. The texture has the effect of considerable movement. *Procedure*: Apply thin coat of color texture with trowel or paint brush. Then add heavier texture with rubber sponge, using face of sponge in a slightly swirling up and down motion. Draw triangle lightly over surface to create highlights. *Courtesy National Gypsum Company.*

Plaster Problems and Their Solution

Gypsum plasters are a highly sensitive chemical product and therefore subject to changes resulting from use under adverse conditions. A knowledge of the effect of these conditions on gypsum plaster as recommended by the *National Gypsum Company* is covered in the following table If these recommenda-

tions be followed a satisfactory correction of practically all plaster problems will be obtained.

Table I.--Precautions and Remedy in Plaster Applications

(Courtesy National Gypsum Company.)

SLOW SET: If plaster fails to set in 4 hours with all proper precautions

REMEDIES (1) Add amount Gold Bond Accelerator (usually handful to the bag is sufficient) necessary to give desired set. Sprinkle accelerator over dry plaster before mixing

or (2) Add handful screened dry set plaster droppings same manner as accelerator

or (3) Add alum or zinc sulphate in proportions two ounces per gallon water (Portland cement is also a good accelerator.)

QUICK SET If plaster sets in box or before it can be darbied

REMEDIES (1) Check to see if mixing box, tools and sand are clean and clean water used

(2) Use retarder or ground glue in amount needed for desired set.

SHORT WORKING If mortar works hard, does not carry sand, drops easily from wall

REMEDIES (1) See material is stored in dry place

(2) Add fresh plaster bag to bag

(3) Decrease amount sand and water

PLASTER TROUBLES AFTER APPLICATION

IF PLASTERED WALL IS	THE TROUBLE IS	REMEDY	TO PREVENT TROUBLE IN FUTURE
Soft, white, chalky, particularly over openings. Hot weather condition	Dry Out. Plaster dried before setting	Spray walls with clean water. Keep wet till set	Screen openings. Wet lath and floors. Avoid drafts. If plaster slow set use accelerator
Damp, Soft. Winter condition	Sweat Out. Plaster holds water and rots	After plaster is set open doors and windows. Supply heat	Allow ventilation in drying after plaster is set. Supply artificial heat in cold weather
Soft, resembling sweat out. Rooms have been at freezing temperature	Walls are frozen	Throw open building. Let walls freeze dry	Keep walls from freezing until plaster is dry or at least 24 hours
Soft, not due slow set or hot weather or retempering plaster	(1) Too much sand (2) Too fine sand	None	(1) Measure sand accurately. Do not use over 3 parts by weight (2) Use coarser sand
Wood lath. Cracks or bulges horizontal with lath Straight vertical cracks	Due swelling, poor grade of lath or improperly spaced or failure to wet [illegible] Failure stagger joints	Remove and replaster	Use No. 1 lath white pine cypress or spruce free from bark, sap or knots. Space 1/4" to 3/8" apart. Stagger. Wet lath before plastering
Gypsum lath. Cracks around joints	Too thin coat	Apply second coat	Use proper grounds
Metal lath. Sags, cracks, does not adhere	Too light lath, too wide spaces, plaster not double fibered. Plaster oversanded	Reapply	Correct conditions mentioned
Brick or tile. Small cracks	Failure wet before plastering. Too little sand. One coat work	Float crack or apply more plaster	(1) Wet tile before plastering (2) Use 3 part sand (3) Two coat work
Concrete. Poor bond	Use of improper plaster. Unprepared surface	Remove loose plaster. Condition wall. Apply bond plaster	Surface must be rough, clean. Use concrete bonding coat

CHAPTER 98

Plastering

The process of plastering consists in applying several coats f suitable mortar to a wood or metal lath base to form interior all surfaces of buildings. In applying the mortar, it is

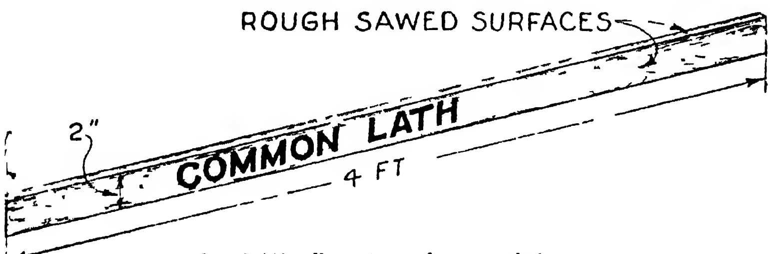


FIG. 5,442. Proportions of common lath

ced through the spaces between the laths, thus forming a eries of keys which assist in holding it firmly against the lath.

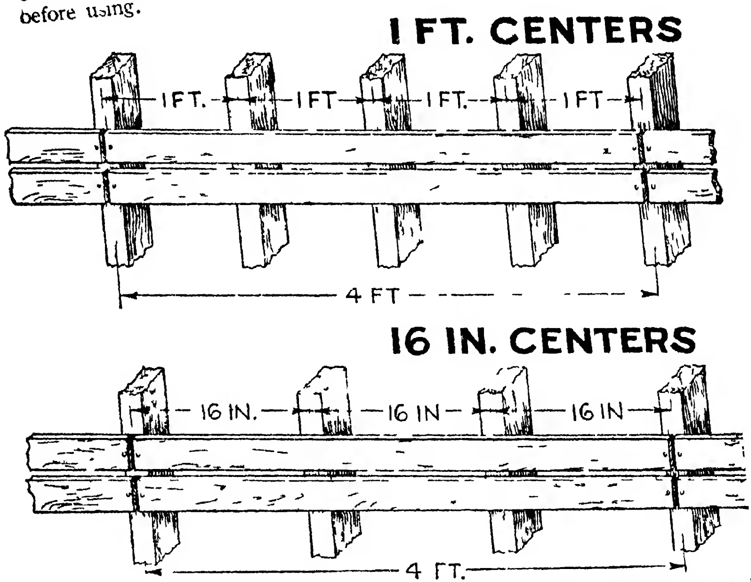
Lath.—The plasterer should know something about lath, ven though it be the carpenter's business to install the lath.

NOTE.—***Wood Lathing.***—All ceilings, walls, partitions and under sides of stairs are to lathed with best quality of lath of full thickness and free from bark. Each joint is to be oken at least every eight course and the lath laid with sufficient space to allow a strong key. ll lath are to be securely nailed to each bearing with 3d fine No. 16 gage wire nails. No breaks ill occur directly over corners of opening. It is sometimes mentioned in specifications that st sawn lath are to be used. This is unnecessary as split lath against which this specification is intended to guard have not been in the market for over 50 yrs. It is also usual to require ry lath to be used. This is a mistake as much better results can be gained by using wet lath, d allowing the mortar and the lath to dry together. Mortar put on dry lath will make them arp and twist, and crack the mortar, should the mortar set or harden before the lath have come saturated. In regard to the clause frequently inserted in the plasterer's specifications rbidding the running of lath over or behind partitions, it would seem to be more effectual to struct the carpenter so to arrange the studs and furring that it would be impossible to make ything else than a solid internal angle.—*Hool and Johnson.*

There are two kinds of lath

1. Wood.
2. Metal.

The best wood for laths is white pine, although spruce is used to a grea extent. Yellow pine should not be used, on account of the pitch which i contains. Half green laths are best for use, although dry laths may be we before using.



FIGS. 5,443 and 5,444.—Why laths are cut to four foot lengths. This length allows the studding to be spaced either 12 ins. or 16 ins. between centers.

Wood laths vary in dimension, the common size being 1½" × ¼" × 4', a shown in fig. 5,442. This allows proper nailing to studding spaced either 1 or 16 ins. on centers, as shown in figs. 5,443 and 5,444.

In nailing, the laths should have a nail to each stud and often two nail are required at the ends of each lath.

The lath should be spaced about $\frac{3}{8}$ ins. apart or about $\frac{1}{4}$ in. for patent or hard plasters, breaking joints about every sixth lath, as shown in fig. 5,445.

When laths have a bearing surface over 2 ins. in width, strips of wood should be placed under the lath so as to allow a space for "keying" the plaster. The sectional view, fig. 5,446, illustrates how the plaster, by spreading out behind the lath, keys itself securely to the lath.

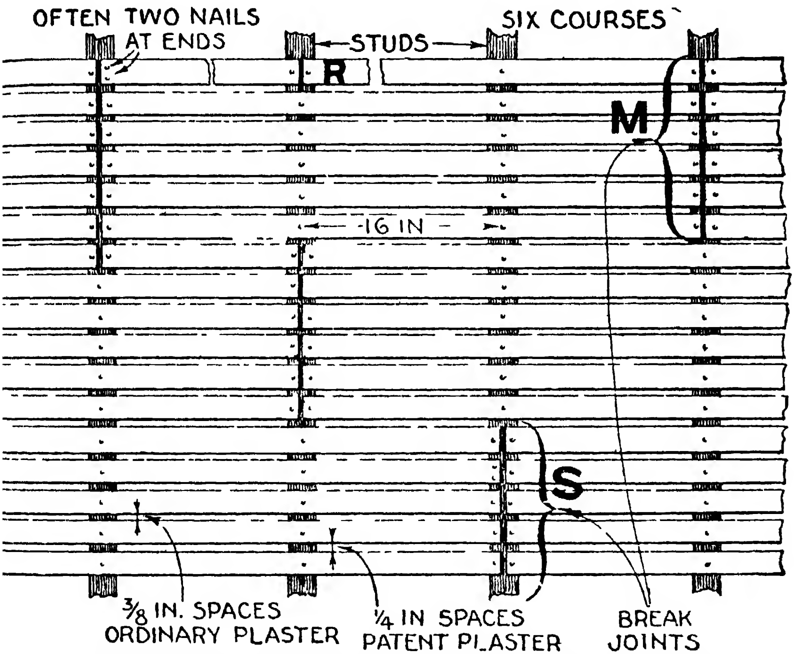


FIG. 5,445.—Section of lathing nailed to studs illustrating the breaking of joint about every sixth course as at M, S, and R, also method of nailing and spacing.

Wood lath are sold by the 1,000, in bundles usually containing 100 lath. Fig. 5,447 illustrates the approximate number of lath required per 100 sq. yds. of wall and the time required by a good lather.

Grounds.—In order that the plasterer may make walls true and of uniform thickness about the doors and window openings and along the floor, "grounds" must be provided.

By definition, *grounds* are *strips of wood for the purpose of assisting the plasterer in making a straight wall and in giving a place to which the finish of the room may be nailed.*

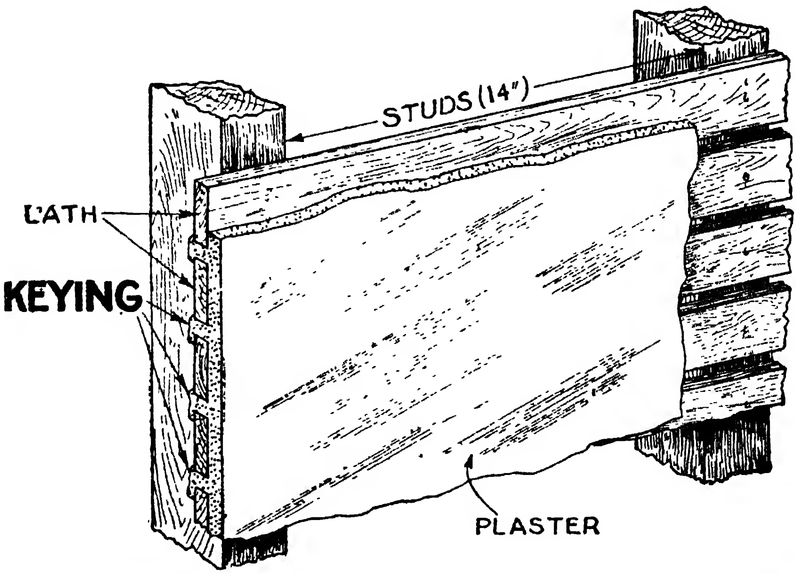


FIG. 5,446.—Section of plastered wall illustrating *keying*, or locking secured by the plaster projecting back of the laths.

Fig. 5,448 illustrates these grounds. For ordinary lime plaster grounds are usually ¾ to ⅞ in. thick by 2 ins. wide.

For hard wall plaster common thickness is ¾ in. with wood lath. Where pulp or fibre plaster is used ⅝ in. should be allowed for both lath and plaster.

It is good practice to set grounds about ⅛ in. narrower than the finished work, so as to allow for the thickness of the finish coat.

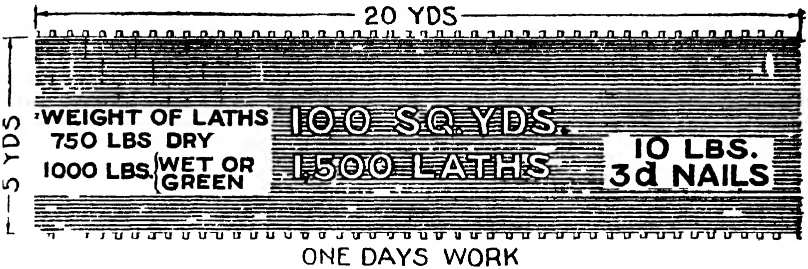


FIG 5 447 —Properties of lath 100 sq yd section lathed illustrating number of lath required, weight nails required and labor

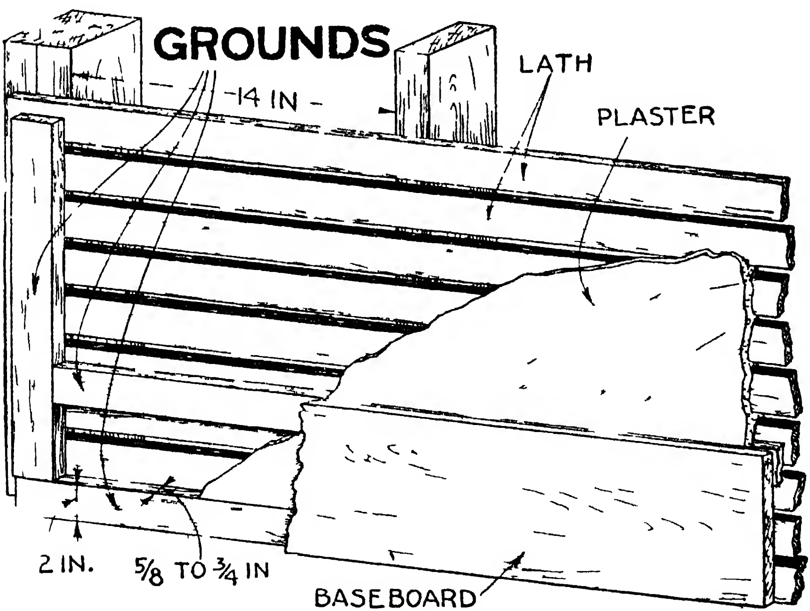


FIG. 5,448 —Section of plastered wall illustrating *grounds* In order to keep out vermin and cold grounds for base should be placed so that the wall may be lathed and plastered down to the floor

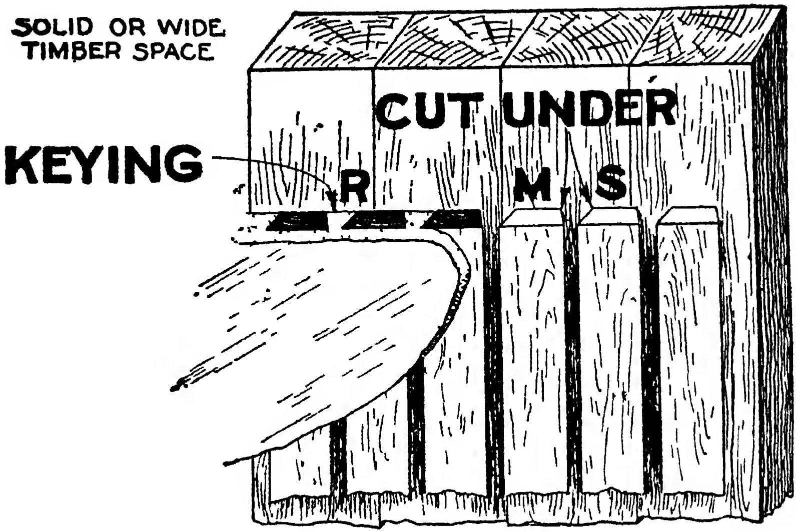


FIG 5 449 —Treatment of lath nailed to broad timber When the timber is over 2 ins wide the lath be "cut under" as at M and S this provides for proper keying as at R

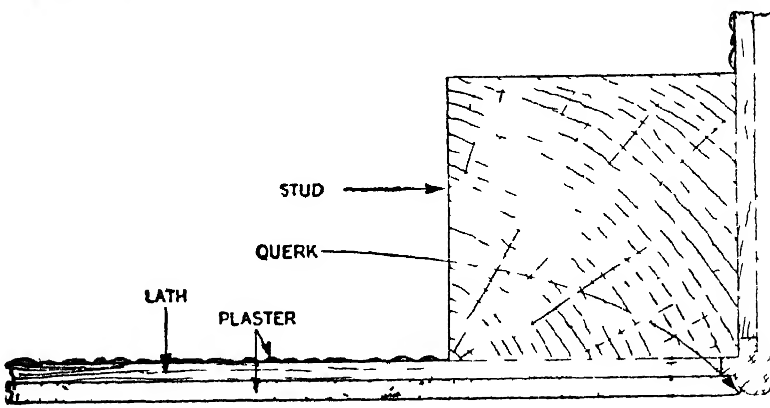
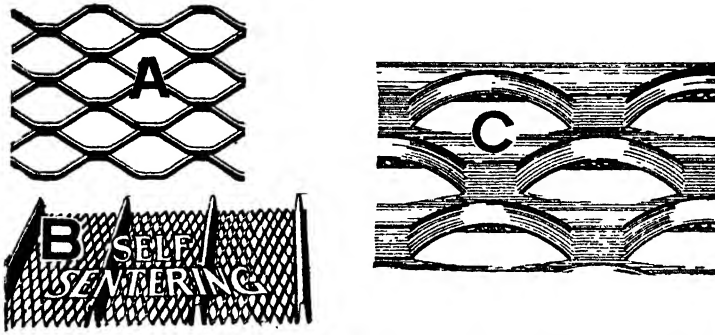


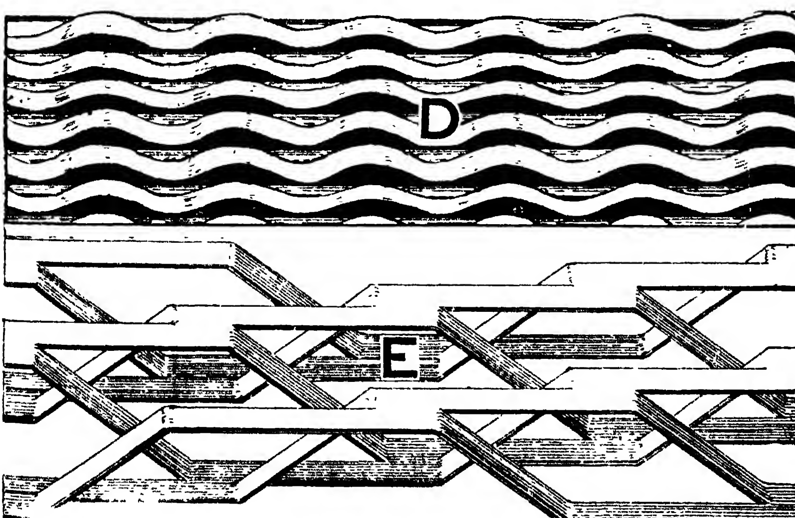
FIG 5 450 —Plaster or corner bead Although this makes more work for the plasterer as the plastering has to be stopped against it forming a *queck* yet it is still used to some extent because if well done it makes a good looking and substantial corner

Metal Lath.—There is a great variety of metal lath now obtainable. These may be classified as

1. Expanded metal lath:

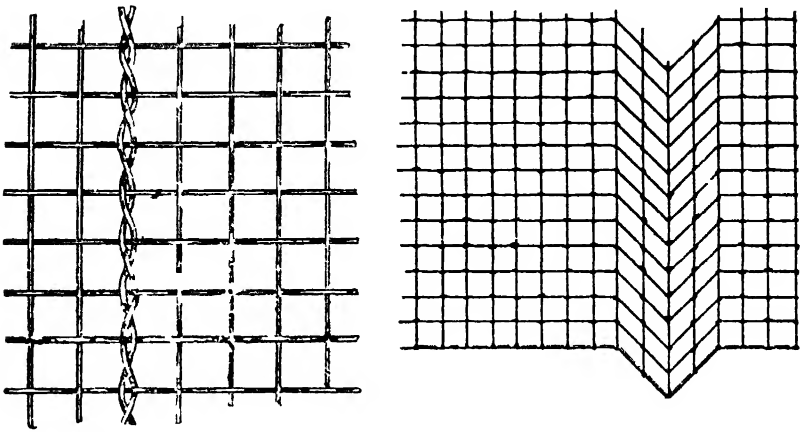


FIGS. 5,451 to 5,453.—Expanded metal lath. **A**, diamond and rectangular mesh, **B**, ribbed and corrugated, **C**, integral combining functions of both lath and studding

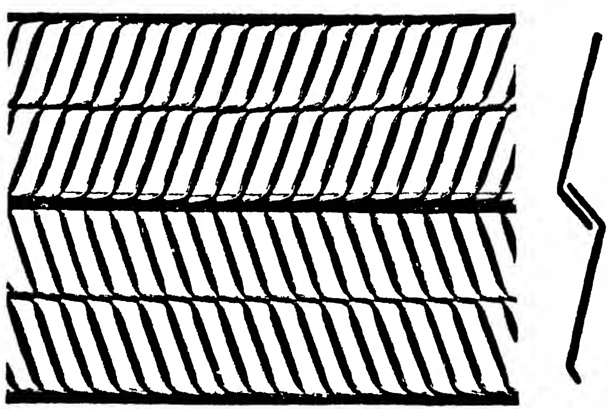


FIGS. 5,454 and 5,455.—Sheet metal lath. **D**, flat perforated; **E**, integral, combining functions of both lath and studding.

a. Diamond and rectangular mesh
b. Ribbed and corrugated
c. Integral, combining functions of both lath and studding



FIGS. 5,456 and 5,457.—Wire woven lath A, flat perforated B, integral combining functions of both lath and studding.

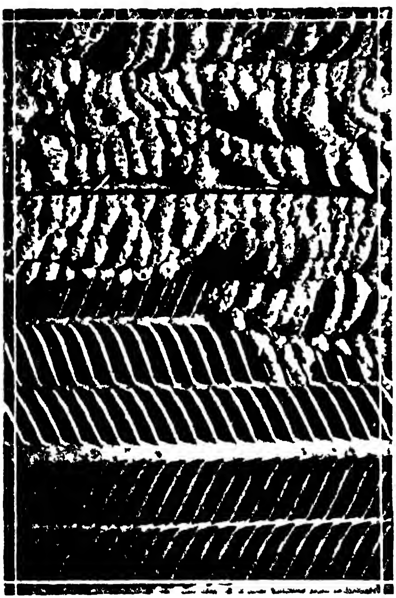


FIGS. 5,458 and 5,459.—Herringbone metal lath. The longitudinal ribs are set at an angle of 45° and the cross strands are flattened. The ribs act as shelves and hold the mortar. The cross strands curl the plaster behind the lath completely covering it.

2. Sheet Lath·

a Flat perforated
b Integral, combining functions of both lath and studding

3. Wire woven lath.



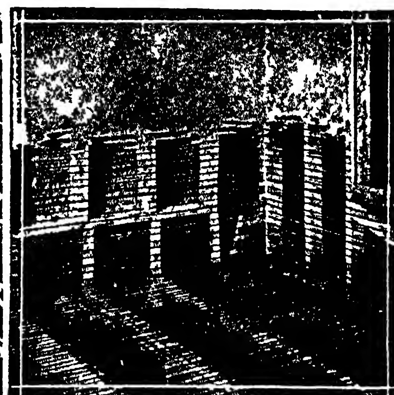


Fig. 5,460. Herringbone metal lath partly plastered as seen from the back showing the effect of the slanted ribs in causing the plaster to key itself and embed the lath.

Fig. 5,461. Herringbone metal lath in position on stud and partly plastered.

a Plain
b Stiffened

Various metal laths and methods of using them are illustrated in the accompanying cuts.

Wall Boards.—These are thin boards made of various materials. They may be divided into two general classes, according to their function as

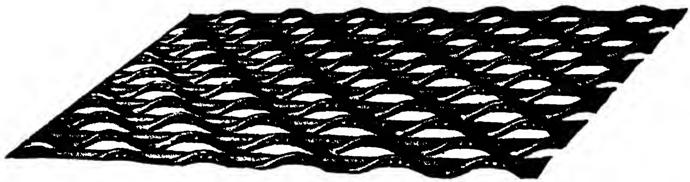


FIG 5 462 —Bostwick Truss loop metal lath There are 652 metal trusses in a sq yd

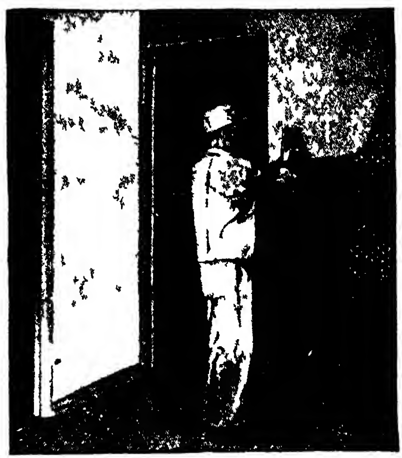


FIG 5,463 —Bostwick Truss loop metal lath in place on studs and partly plastered

1. Plaster boards
2. Finish boards

Plaster boards are used instead of wood or metal lath and are of service as a fire proof covering or for sound deadening.

A common size of plaster board is 32 × 36 of various thicknesses, ranging from 1/4 to 1/2 in

These boards are light (standard board weighs $1\frac{1}{2}$ lbs. per sq. ft.). They are intended to be nailed directly to the studding and plastered over the same as lath. In nailing, the boards are placed with the plastering side out, and the center of the board nailed first and edges last.

The grounds to be provided will vary from $\frac{3}{4}$ in. (for $\frac{1}{4}$ in.

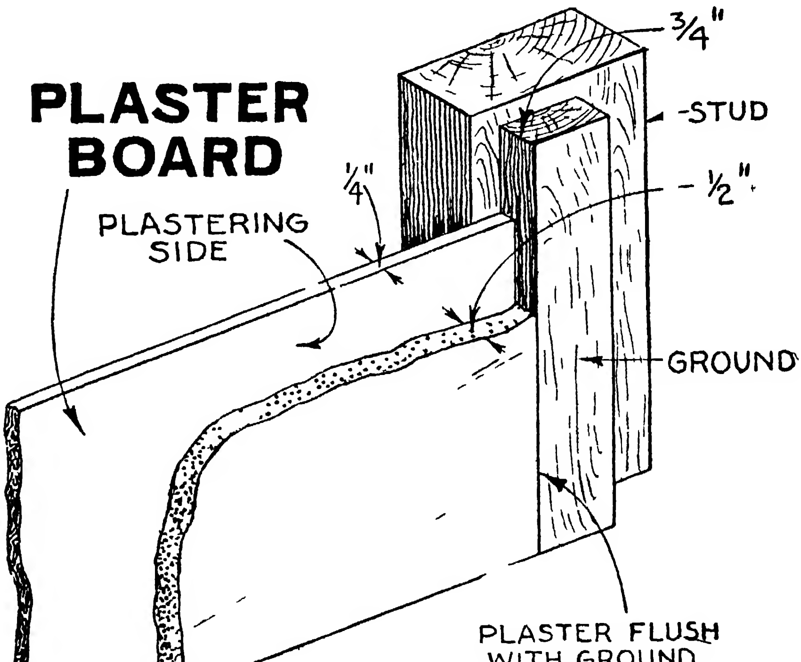


FIG. 4,164.—Sackett plaster board, sectional view showing $\frac{1}{4}$ in. board nailed to studs and covered with plaster. Sackett plaster board is made in two thicknesses, $\frac{1}{4}$ in. and $\frac{3}{8}$ in. and should be plastered with $\frac{1}{2}$ in. of plaster.

boards) to $\frac{7}{8}$ in. (for $\frac{3}{8}$ in. boards). A space of $\frac{1}{4}$ in. is left between boards and each edge of the board must have a bearing on the nailing piece of at least $\frac{3}{4}$ in.

In applying on studding or joists, use $1\frac{1}{2}$ in., $11\frac{1}{2}$ gauge, $\frac{5}{16}$ head smooth wire nails spaced 4 ins. apart, driving each nail in firmly. These plaster boards require but little plastering material.

When this saving is considered they cost less than metal lath and but little more than wooden lath with three coats of plaster.

Finish boards are primarily intended for use as an interior

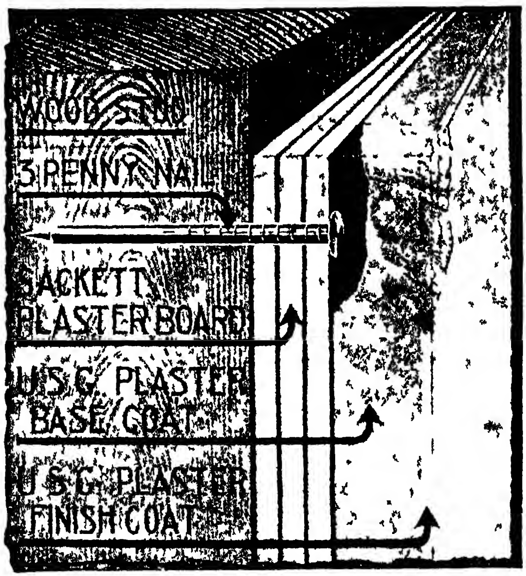


FIG. 5,465.—Sackett plaster board sectional view showing in. board nailed to studs and covered with plaster. Sackett plaster board is made in two thicknesses $\frac{1}{4}$ in. and $\frac{3}{8}$ in. and should be plastered with $\frac{1}{2}$ in. of plaster.

finish on side walls and ceilings in buildings of all classes. They may be used in all situations where finishes of lath and plaster may be used, and in many places where the latter finish is not suitable.

One form of wall (finish) board known as the "Best wall" consists of a

single layer of fibre calcined gypsum, surfaced on each side with specially prepared waterproofed paper securely bonded to the surface

It is 3/8 in in thickness and is furnished in stock sizes 47¾ ins wide and in lengths of 5, 6, 7, 8, 9 and 10 ft The finished product presents a smooth surface which is light cream in color on the face side and gray on the reverse side. The edges are slightly beveled to provide for the filling of the joints

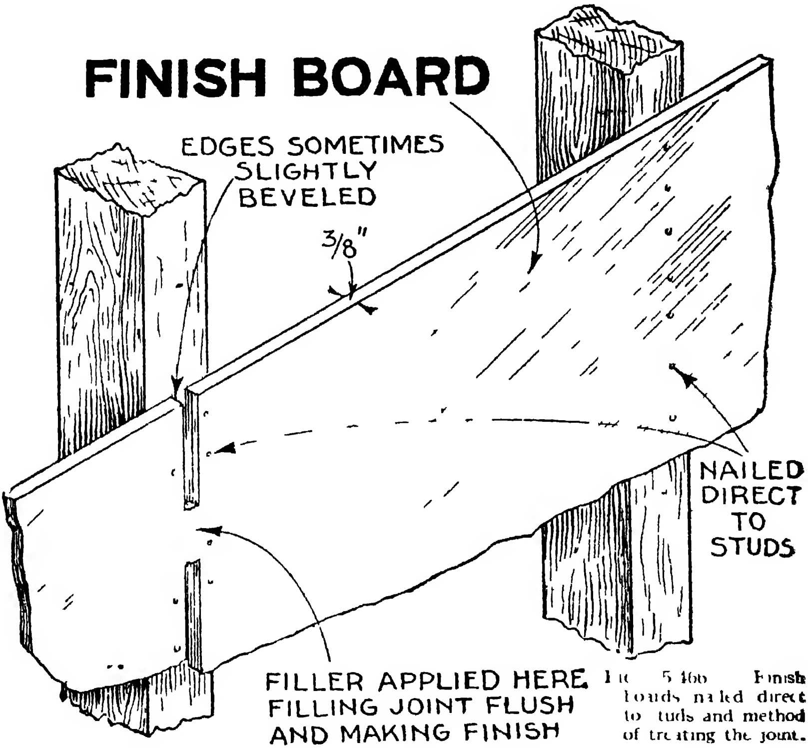


Fig. 5,466 Finish boards nailed direct to studs and method of treating the joint.

and are doubly reinforced Weight about 1 850 lbs per 1 000 sq ft Finish wall boards are applied by nailing direct to the studding, joists or furring and filling the joints between the boards with a specially prepared filler of the same composition as the core of the board In nailing *3d* fine wire nails are used, spaced from 2 to 3 ins at the edges and from 8 to 12 ins at the intermediate supports Filling in the joints consists of two operations first,

roughing in, and second, *trowelling out* to a smooth finish flush with the surface of the boards The boards are cut and fitted either with a saw, or by scoring and breaking over a straight edge

The boards after being installed may be painted or covered with wall paper if desired Fig 5,466 shows detail of finish boards nailed to studs and treatment of the joint

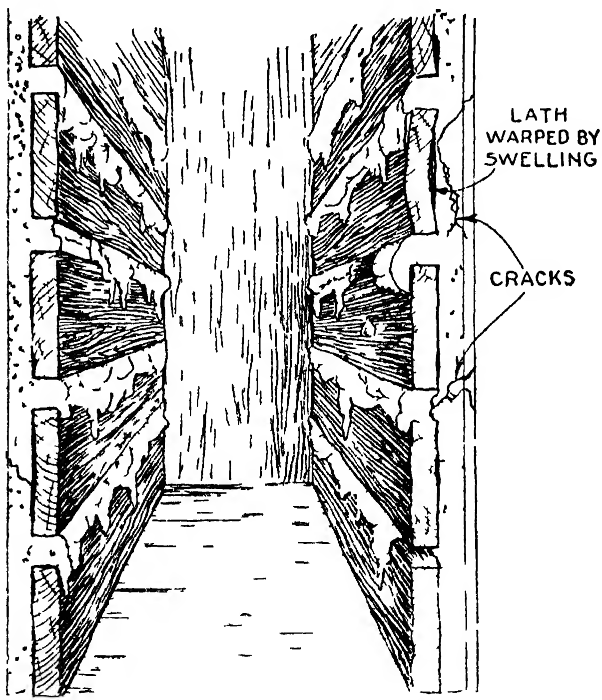


FIG 5 467 —Sectional view through partition wall showing how the plaster is cracked by the swelling of the lath This happens in case the lath be too dry when plastered Hence it is well to wet the laths so that they may swell before the plaster is applied

Another and decorative method of treating the joints between the boards is by paneling that is by nailing strips over the joints

It is possible to vary the amount of paneling strips and employ any design that will best cover the joints, using the wall board to best advantage

in proportioning the layout to suit the size of room. The ceiling in perspective is the same as that on plan except that the small center panel is not shown and can be omitted.

A dado may be carried around over window openings without any strips reaching to the ceiling, or they may extend to ceiling without dado or in corners with dado.

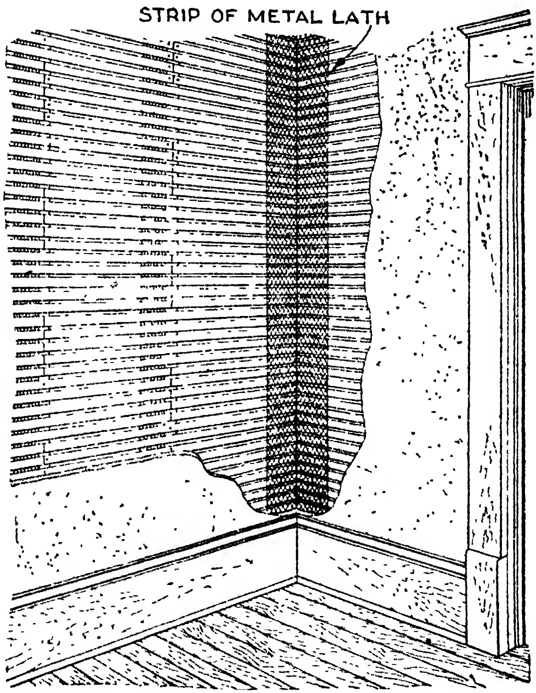


FIG. 5,468.—Corner in room showing spacing of wood lath, plaster and trim. ***Lath required:*** A bundle of 100 $1\frac{3}{8}''$ wide and 4′ long lath will cover a flat surface 7′ × 8′ or 56 square feet, spaced about $\frac{3}{8}''$ apart. By reference to tables in Vol. I, of the Carpenters and Builders Guides it will be seen that lath nails are 1 in. long and average about 300 to one lb.

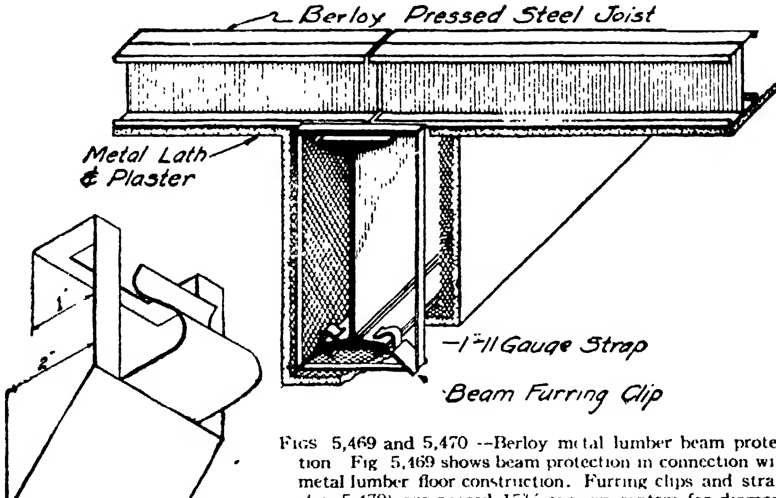
In a dining room or den, a dado (wainscote) may be suggested by stripping. What the room is used for and its size influences the layout.

The use of wall board covers a wide range of use. A dilapidated ceiling or side wall may be renewed with it, putting it on over the plaster, or an

unfinished attic may be converted into living quarters without the inconvenience of plaster, and can be accomplished much quicker.

Plasterer's Materials.—The following materials are used in making the mortars for the various coats used in plastering.

Lime.—Such as is used for ordinary building purposes is obtained by calcining or burning calcareous minerals; that is, common limestone or carbonate of lime which has been



FIGS 5,469 and 5,470 —Berloy metal lumber beam protection Fig 5,469 shows beam protection in connection with metal lumber floor construction. Furring clips and straps (fig. 5,470) are spaced $15\frac{3}{4}$ ins on centers for diamond mesh lath and 24 ins. on centers for $\frac{3}{8}$ in. Ribplex The lath or Ribplex is securely wired to the straps and plaster is applied of composition to afford protection.

deprived of carbonic acid and water by the action of heat becomes *lime*.

Pure limestone or that which is nearly so will bear intense white heat without detriment. On the other hand, compound

NOTE.—*Panel Strips.* These may be had or made in a great variety of patterns. In regular stock they are usually plain, $\frac{1}{4}\times1\frac{1}{8}$ and should not be less than $\frac{5}{16}\times1\frac{1}{2}$; $\frac{3}{8}\times2$ ins. is better. Rectangular strips are most generally used because the square butt joint is easier and quicker to erect and admit of some slight variation either way from its point of intersection, and remains a perfect joint.

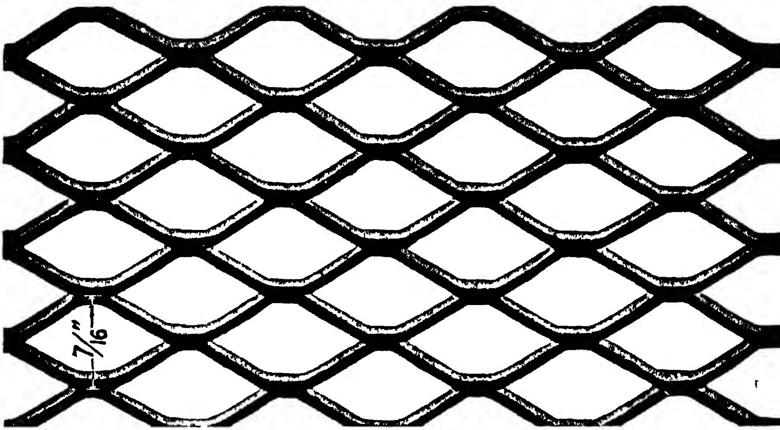


FIG. 5,471.—Eureka metal lath. Especially adapted for work not requiring a small metal lath. This lath can be used with [illegible] on many types of plastering work for which a small mesh lath is not required. This is particularly true in the case of solid plaster partitions, or if there be an excessive amount of plaster shoved through the lath, it only serves to build up the first coat that must of necessity be placed on the reverse side of the lath.

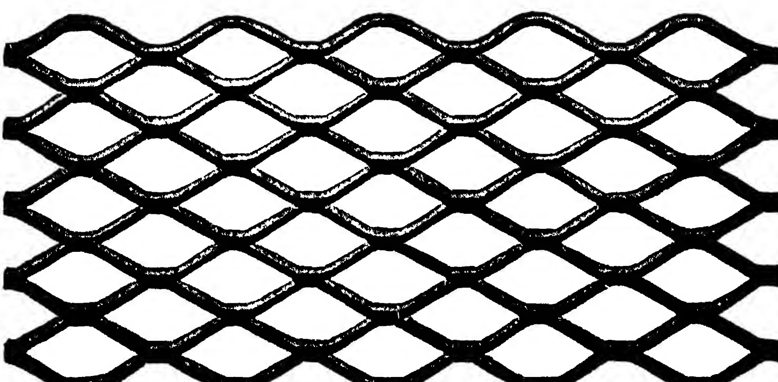


FIG. 5,472.—XX Century expanded metal lath. Acid proof – not affected by severe climatic condition. This lath is designed to meet a growing need for a lath that is proof against acid corrosion, and for damp or rigorous climates. It is indicated for use with any plastic preparation which contain acids and also where the finished work is subject to dampness.

limestone, alloyed in its proportions to form hydraulic lime fuses easily, and its calcination needs certain precautions, so that common red heat is sufficient for this kind, the intensity being compensated for by its longer duration; except in the manufacture of Portland cement from argillaceous limestone, which contains from twenty to twenty-two per cent of clay;

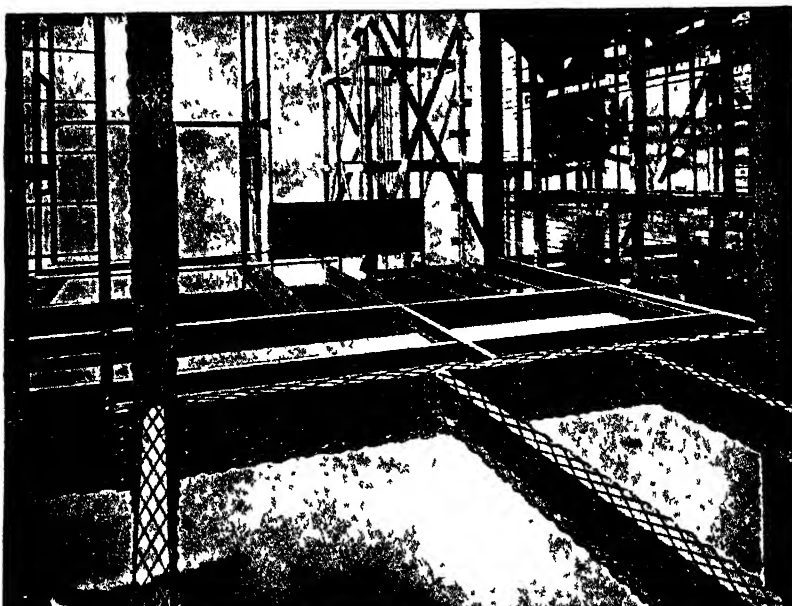


FIG 5,473 —Kno-fur self furring metal lath, adapted for use in Southern or Sea Shore work or whenever dampness or unusual atmospheric conditions prevail this for the reason that it is cut from copper bearing sheet and further protected by a coat of carbon paint

when a heat of great intensity, as well as longer duration, is required. Frequently it will not slack (or slake) but becomes reduced, after some days, to a harsh powder almost inert and useless.

Both the pure and compound limestones when burnt insufficiently either do not, or only partially slack, leaving a solid kernel or kind of sub-carbonate with excess of base.

The following are the characteristics of the various limes:

1. ***Rich limes*** consist of pure metallic oxides of calcium. They increase in volume to twice their original bulk or even more when slaked with water,

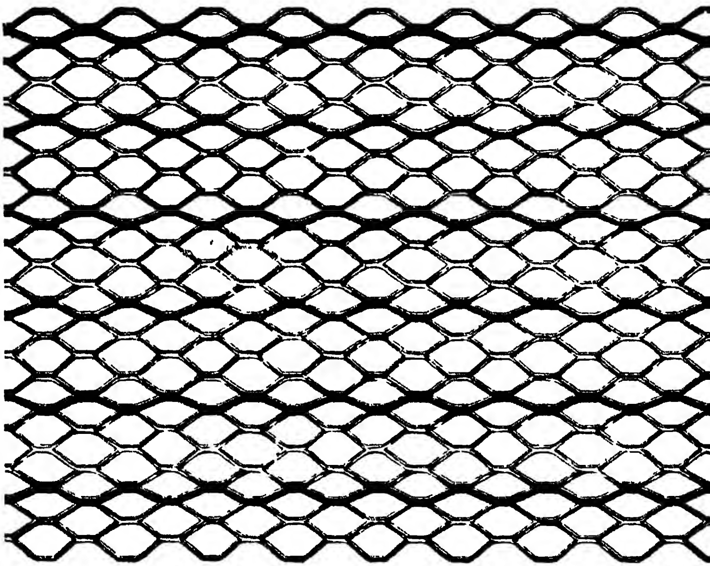


FIG. 5,474 Corrugated expanded metal lath. ***The corrugations*** which act as furring strips are ¼-inch deep and spaced 1 inch apart running lengthwise of the sheets. Since these corrugations are open meshes they will completely embed in the plaster and insure a perfect "key" over the entire plastering surface. And in addition they add materially to the reinforcing value of the lath.

and will not set under water unless mixed with other materials.

2. ***Poor limes*** are those which do not or only slightly swell or increase in bulk when slaked.

3. ***Semi-hydraulic limes*** set under water in from fifteen to twenty days, but do not become very hard.

4. ***Full hydraulic limes*** set in from six to eight days' immersion and continue to harden for some months

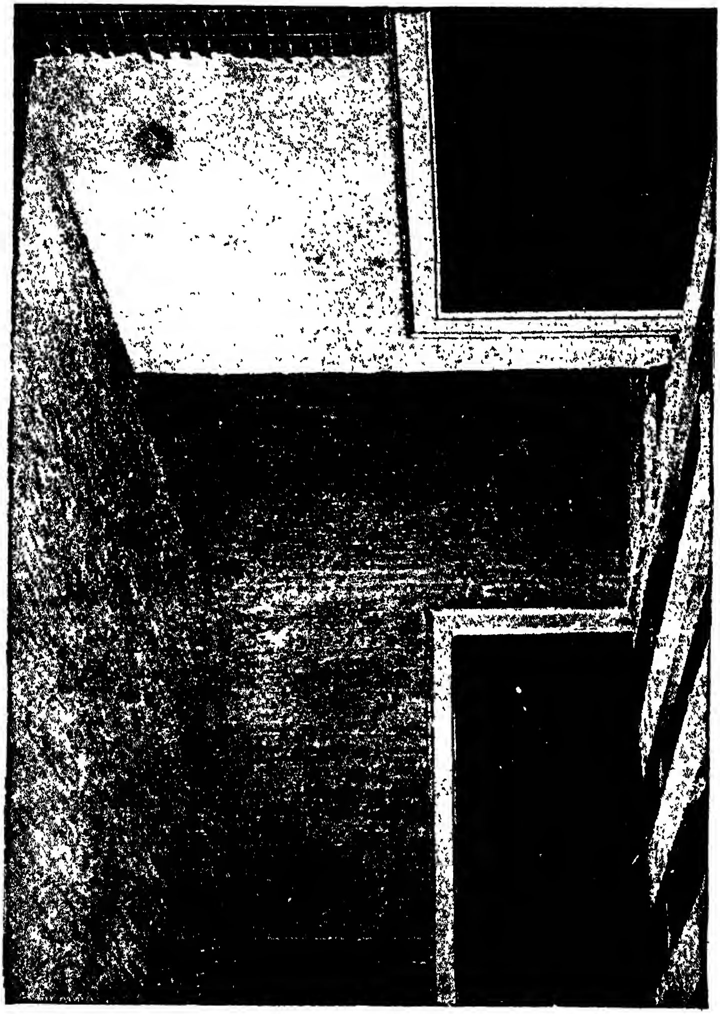


Fig. 5,475 —National stucco plaster reinforcement as applied to walls and ceilings of a school room.

5. ***Eminently hydraulic limes*** set within three or four days or less and are quite hard in a month.

Calcined Plaster.—Gypsum plaster, ground fine, calcined and finely sifted, is that used for hard, white finish, stucco work, etc., white or bluish white being the best colors for general use, commonly called *plaster of Paris*.

Gypsum rock is a mineral, calcined, is a basic product, forms a plaster mass by the addition of water, and upon crystallizing or setting, unites chemically.

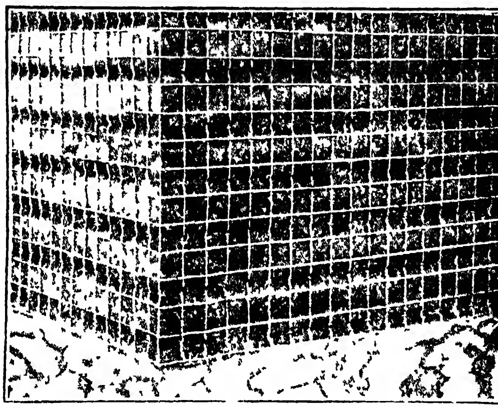


FIG. 5,476 —National stucco plaster reinforcement applied around corner.

Sand.—This is formed originally from the decomposition of old rocks and is distinguished from dust by the fact that it sinks to the bottom of a vessel of water. There are several kinds of sand known as:

1. Pit sand.
2. River sand.
3. Virgin sand, etc.

Pit sand is generally "sharper" than river sand but there is little difference except it is often of an ochre or yellowed tinge, likewise bank sand.

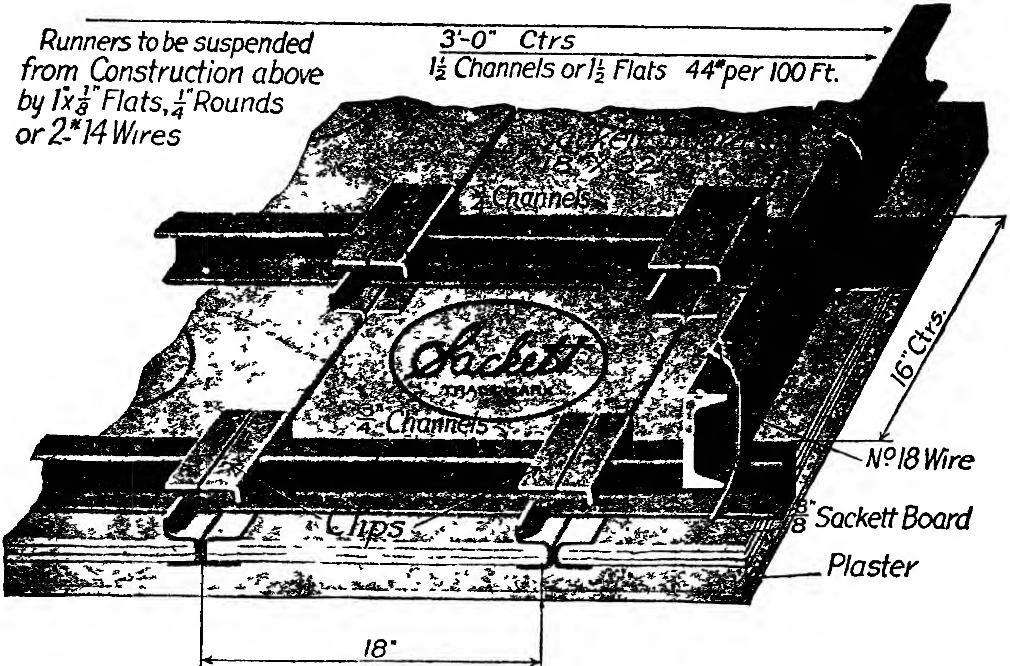


FIG. 5,477.—Jester Sackett suspended ceiling. The ceiling is formed of Sackett plaster board with the Jester ceiling clips. Boards 3/8 in. Sackett, 18 × 32 ins. in size attached by means of Jester clips to 3/4 in. standard or Sharon channels spaced 16 ins. on centers. These 3/4 in. channels to be attached by means of No. 16 tie wire to 1 1/2 in. channels spaced 4 ft. apart, which latter are to be suspended from the construction above by 1 × 1/8 in. flat iron straps or 1/4 in. round rods or two No. 14 galvanized wires, not to exceed 4 ft. on centers bent around them and wired securely. Hangers are provided by the contractor and set in concrete by the mason contractor.

Lake sand is the same quality as river sand.

Sea sand is not desirable for plasterers' use since the grains have been rounded and smoothed by the action of the water, which prevents them adhering properly. Moreover since salt absorbs water, the use of sea sand with its salt coating results in a damp wall.

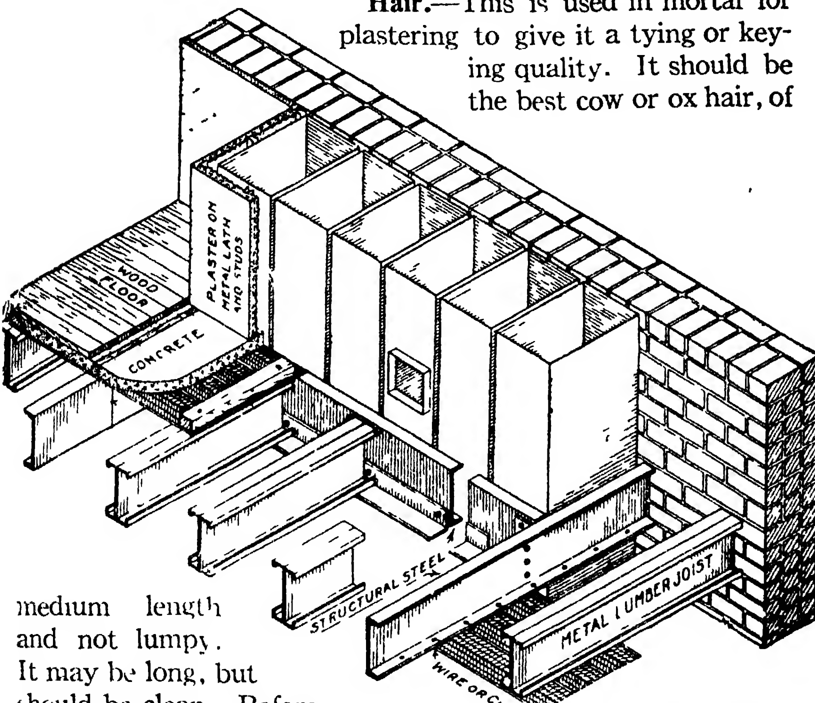
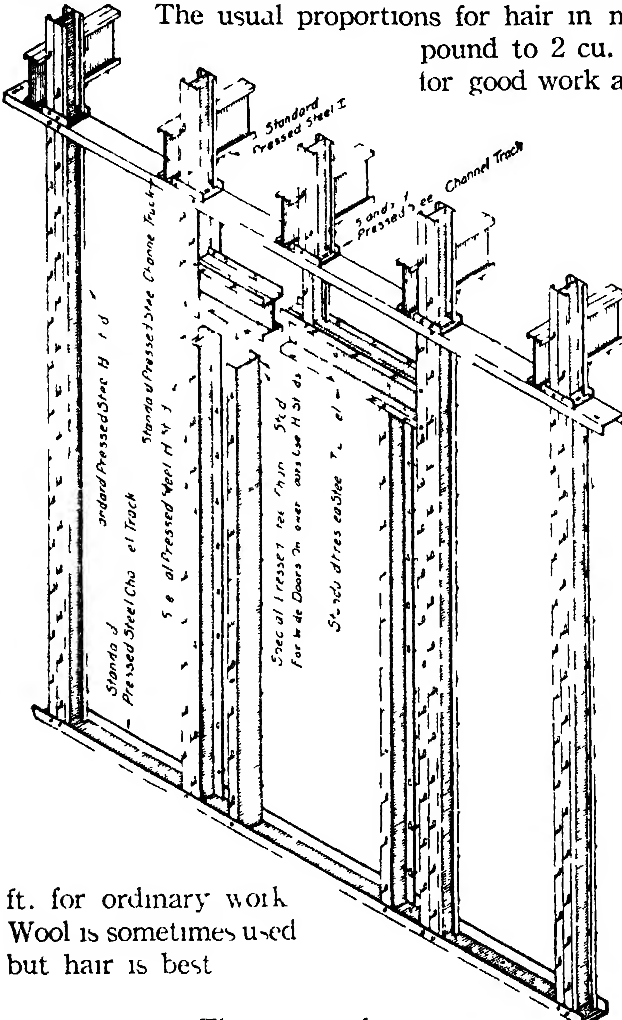


Fig. 5,178 — Berloy metal lumber. Typical floor opening around ducts, elevators, large skylights and stairways. Principal framing of structural steel.

Hair.—This is used in mortar for plastering to give it a tying or keying quality. It should be the best cow or ox hair, of medium length and not lumpy. It may be long, but should be clean. Before it is mixed with mortar it should be beaten up by placing it on a mortar board, bench or table and beating it up thoroughly with two laths or rattans until the matted portions are entirely separated. This is usually done by the

plasterer's helper or laborer who keeps at it until fit for use. The usual proportions for hair in mortar is one pound to 2 cu. ft. of mortar for good work and 1 to 3 cu.



[illegible] 5,4[illegible] Br[illegible] [illegible] lum[illegible] Socket strips [illegible] studs for solid [illegible] tition [illegible] socket [illegible]ps insure per[illegible] [illegible] alignment [illegible] regular spacing of studs. [illegible]cket strips can [illegible] fastened at irregular inter[illegible] wherever convenient and [illegible] will provide a secure anchorage for a long run of studs.

ft. for ordinary work. Wool is sometimes used but hair is best.

Saw Dust.—This material is sometimes used

in mortar for plastering the outside of walls to offset the action of frost and water and prevent the plaster scaling. It should be free from chips and shavings.

Brick Dust.—As a coloring material, brick dust is often employed in finishing. It should be sifted through a fine sieve.

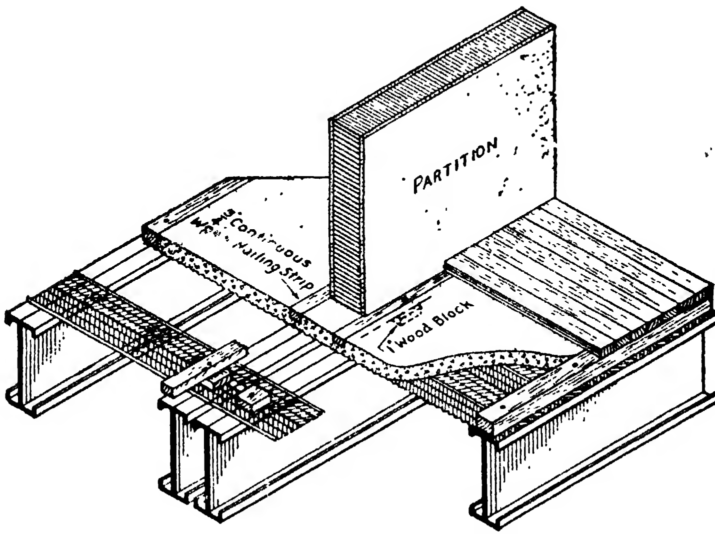


FIG. 5,480.—Berloy metal lumber. Floor and partition construction showing double joists on the partition and method of nailing wood floors.

Brick dust is also used to mix with mortar so it will set quickly, giving it the quality of hydraulic cement mortar.

Coloring Materials.—There are various materials used in coloring mortar, listed as follows:

Lamp black	Ultra marine blue
Drop black	Indigo blue

Ivory black	Blue vitriol
Powdered charcoal	Spanish brown
Red analine	Raw umber
Venetian red	Burnt umber
Indian red	Chrome yellow
Vermilion	Pulverized clay

Various colored sands

Plasterers' Tools.—The assortment of tools used by the

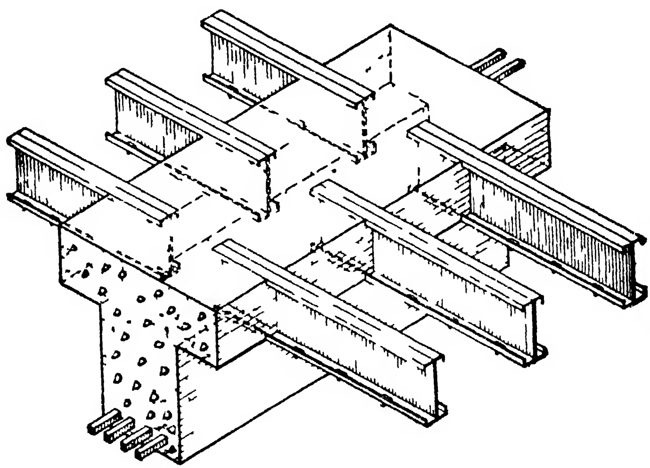


FIG 5 181 —Berloy metal lumber Detail of floor construction When joists extend into the stem of the concrete girder the stem should be wide enough to allow two inch bearings with space between ends of joists for bent up bars if used

plasterer are similar to those employed by the bricklayer. The essential tools are:

Trowel	Float	Long rod	Brush	Mitering tools
Hawk	Scratcher	Angle block	Paddle	Trammels
Darby	Straight edge	Pointer	Moulds	Mortar hod

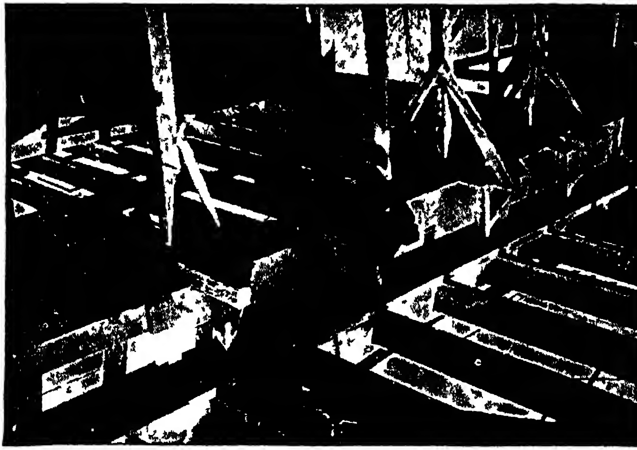


FIG. 5,482 Berloy metal lumber joists used in connection with reinforced concrete framing.

FIG. 5,483 —Top view of same construction shown in fig 5,482 illustrating details of form work This illustrates also the simplicity of form work where metal lumber is used in connection with reinforced concrete superstructure

In addition a shovel, hoe, sand screen, mortar box, pail, etc., are needed in mixing the mortar.

Trowel.—As distinguished from the bricklayers' trowel, the plasterers' trowel is rectangular in shape as shown in fig. 5,484. The handle is attached to a mounting which stiffens the blade. The latter is light, so that the tool is easily used. Trowels are classed as

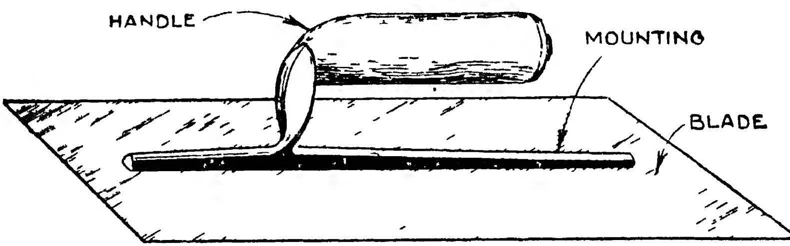


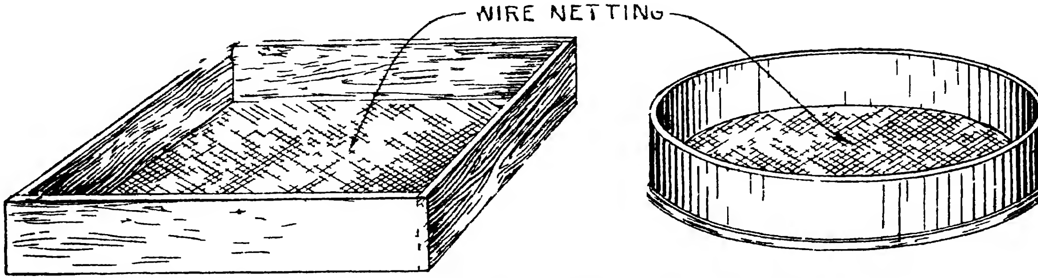
FIG. 5,484.—Finishing trowel, made of 24 gauge trowel steel, polished and etched. The mounting extends within ¾ in. from each side of blade and contains ten large rivets, this leaves ample spring for finishing, also prevents lime working between blade and mounting. Handle is shaped to fit the hand. *Usual sizes:* 10½, 11 and 11½ ins.

1. Browning.
2. Finishing.

The browning trowel is used for rough coating and has a heavier blade than that used on the finishing trowel, otherwise the construction of both are the same.

Sand Screens and Hods.—As used by plasterers, are similar in form and make to those used in bricklaying, which are illustrated in the section covering that subject. Similarly also

NOTE.—Key to reference letters used on the accompanying illustrations of Berger's metal lumber. A, prong; B, T stud for solid partitions; C, socket for T, stud; D, socket for U stud; E, channel stud for hollow partitions; F, socket for channel stud; H, angle socket strip for T studs; I, channel socket strip for channel stud; J, angle stud for corners; K, lath; L, furring strips; M, furring clip for attaching furring to I, beams out of level; P, toggle bolt; S, socket for angle studs; U, cornice furring strip; V, U, stud; X, socket strip for U, stud.



FIGS. 5,485 and 5,486.—Putty sieves. FIG. 5,485, home made square box sieve; FIG. 5,486, ordinary flour or meal sieve.

FIG. 5,487.—Three prong hook or drag used for mixing hair in mortar for plastering.

with mortar hods, although those used for conveying lime putty are somewhat larger in bulk carrying capacity.

Putty Sieves or Strainers.—These appliances are used in making lime putty for white or finishing coats. They may be home made by attaching fine wire netting to a $1\frac{1}{4}$in. wooden frame, or they may be purchased from dealers in supplies. An ordinary flour or meal sieve serves the purpose very well.

Hoe.—The type hoe used by the plasterer is exactly like that used by bricklayers' helpers, except that those used in the slaking boxes have holes cut in the blade to allow easier working.

Slake Box.—In size this box should measure about 7½ or 8 ft. in length by 3 ft. width and a foot deep. It may be made of 2 in. planks cleated on ends and fitted with a latticed opening sliding trap or small door on one end to prevent the sediment and lumpy stuff passing through when the door is opened to run off the slaked lime. A box of this kind is shown in fig. 5,489.

Pails.—Plasterers require water and mortar pails. These should be of galvanized iron.

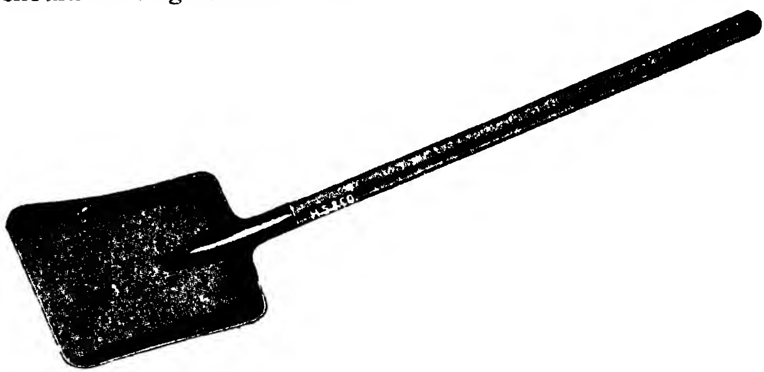


FIG 5,488 —Feeding spade for lifting mortar from pan or box to hawk.

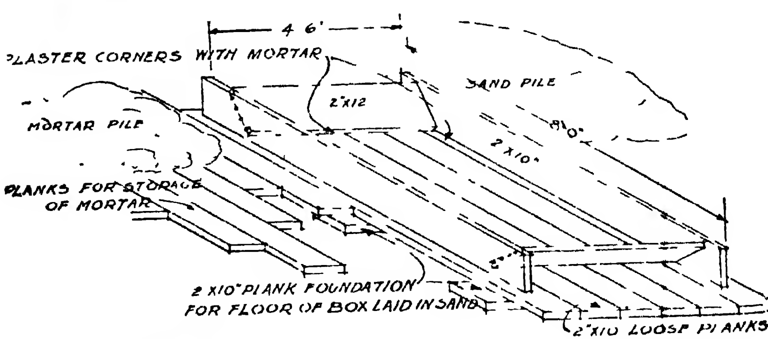


FIG 5,489 – Slake box for slaking the lime

Hawk.—This tool is usually made of hard pine or cedar and is usually about 13 or 14 ins. square. It is held in the left hand as shown in fig. 5,492, forming a small "hand table"

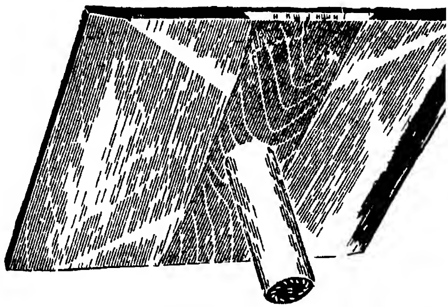


FIG. 5,490.—Wood hawk [illegible]etailed cross piece to which the detachable handle is attached. *Usual sizes*: 13×13, 13½×13½ ins.

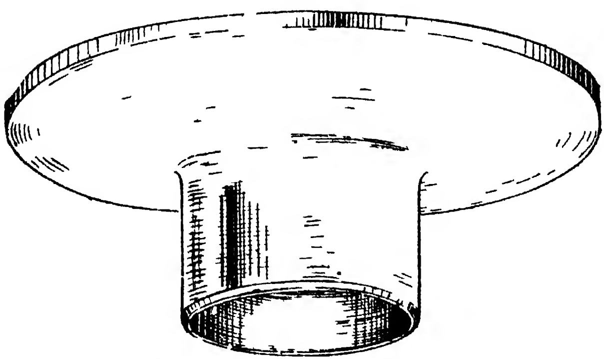


FIG. 5,491.—Plasterer's callous preventer made of soft gum rubber to fit over the hawk handle. It eases up the dead weight of a heavy hawk load of mortar, relieves the unyielding pressure and prevents sore and ugly callouses.

which holds a supply of mortar. The plasterer conveys this mortar from the hawk to the work where he spreads it over the surface to be plastered as shown in the illustration.

Float.—The common form of float consists of a piece of hard pine board 10 or $12 \times 5 \times \frac{5}{8}$ to $\frac{7}{8}$ in. having a wooden handle, preferably of hard wood screwed to the back. Because of the great friction, the face of a float soon wears off and

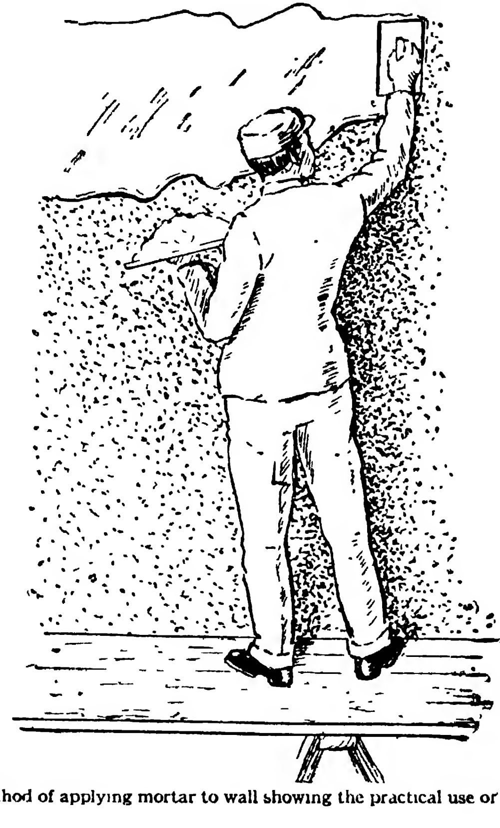
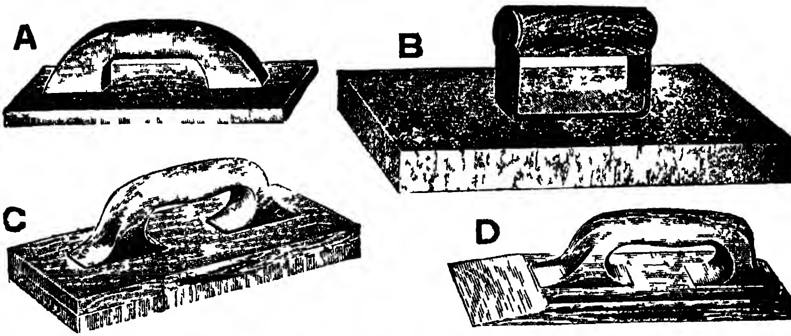


FIG. 5,492.—Method of applying mortar to wall showing the practical use of hawk and trowel

becomes thin; hence, there is usually an adjustable handle fastened with bolts which can be fixed to new face pieces as they may require. In use floats are applied in smoothing and

finishing with a rotary motion sometimes reversed as left to right, and vice versa. Various types of float are shown in figs. 5,493 to 5,496.



FIGS. 5,493 to 5,496.—Various floats. A, common white pine float dipped in linseed oil; B, cork float with handle; C, cork float with wood back handle; D, wood angle float with handle.

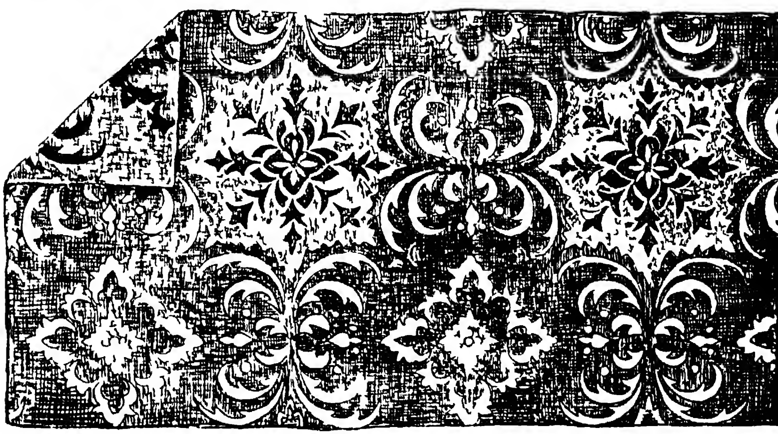


FIG. 5,497.—Brussels carpet for sand finishing. This carpet is for attaching to wood floats when sand finishing.

Darby. This tool is simply a flat straight strip of wood (or metal) provided with handles to enable the workman to level up and straighten large surfaces as they are put on.

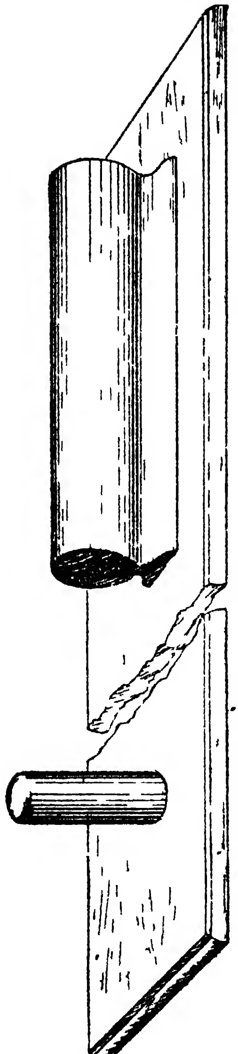


FIG. 5,498.—Wood darby. Usually made of white pine and dipped in linseed oil. Size about $45 \times 3\frac{3}{4} \times \frac{5}{16}$ to $\frac{1}{2}$ in.

In use, the tool is held by both hands and moved with a sliding up and down diagonal rotary and horizontal motion to level off by rubbing and pressing any lumps or high spots which may be left after applying the mortar with the trowels. This work is very laborious, especially on ceilings or any jobs above the line of the shoulders. The tool is essential also in preserving an even thickness of each coat.

FIG. 5,498 shows an ordinary wooden darby.

Scratcher. Usually this tool is made by the plasterer of good straight grained lath well put together as shown in fig.

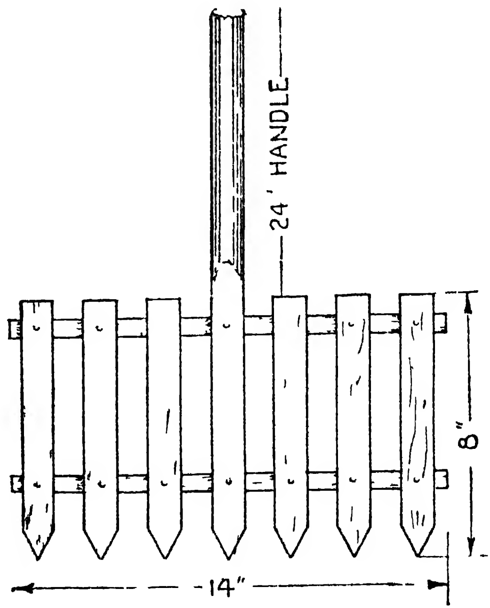
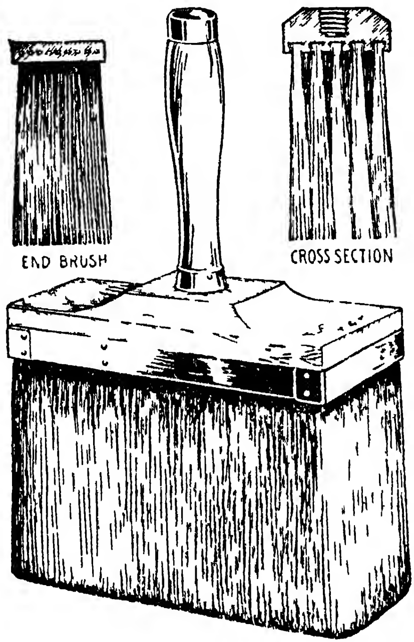


FIG. 5,499.—Home made scratcher as made of lath by the plasterer. The handle should be either oval or round.

5,499. It is used for scratching the first hair or *scratch coat* by scratching grooves in the mortar, bringing up rough edges which serve to hold or key on the second or *brown* coat. In working the tool it is held with both hands.



FIGS. 5,500 to 5,502.—Plasterer's [illegible] brush. *In construction* each row of bristles is fastened into a moulded [illegible] pocket [illegible] each pocket of bristles is mortised into the wood block as shown.

Brushes. The principal brush used by plasterers is such as is used by interior decorators for putting on wall water paints for wetting the wall when hard finishing, is from 4 to 6″ wide, usually the latter, made of best bristle from 5 to 6 inches long. Narrow flat and round brushes are necessary for work

in angles of cornices, embossing and cleaning off. Any large flat brush such as is used for whitewashing is suitable for wetting down, or a whisk broom is very satisfactory for this and also for brushing on cement or sand finishes and over brick work.

FIG. 5,903.—Expanded wood lath as base for stucco. *It consists of* a strip of selected wood, manufactured by specially constructed machines then expanded so as to form longitudinal strips connected by diagonal ribs. The ribs are narrower than the strips so that the plastic covering when applied passes beneath and around these ribs forming a key, thereby becoming an integral part of the structure to which it is applied. The back of the lath is covered with non destructible waterproof asphalt felt.

NOTE.—*Mortar Board.*—Usually made 3½ ft. square of good straight tongued and grooved boards [illegible] thick held together on the back by two thick cleats screwed on and set far enough apart to admit the head of a barrel between them as the board is often placed when in use on the head of an empty lime barrel. Finishing stuff boards are made larger than ordinary mortar board.

NOTE.—*Mortar Beds.*—Usually made of clean 2 in. plank well nailed together. Size 3½×7×1 ft. It should be strongly put together to withstand the heavy mortar pressure.

NOTE.—*Plastering Measurements.* Plastering is generally measured by the square yard, and no deduction is made for door, window or other openings which do not exceed 63 sq. ft. In measuring closets, it is customary to add half of the contents, and if shelves and strips be put in before plastering to double the contents on account of the extra work involved for the same reason, small gables and such triangular or irregular surfaces are also figured "square."

FIG. 5,501.—Three coat plaster work over Bostwick metal lath

FIG. 5,505.—Plasterer applying plaster over "truss loop" metal lath

Plastering.– The operation of plastering on either wood or metal lath is done with one, two or three "coats" or applications of the mortar. One (or two) coats of *brown* or coarse mortar is first put on, and then a hard finishing coat called the *putty coat.*

For the first coat of coarse mortar hair mortar is used, and if no finishing coat be put on, it is just troweled to a smooth surface, after having been darbied and floated down. On lath, one coat is simply "laid" and two coats laid and set.

In the three coat method of plastering on lathing, the coats are known as

1. Scratch coat.
2. Brown or floated coat.
3. Finish or set coat.

When brick or stone walls are being plastered the first coat is called the *rendering* coat

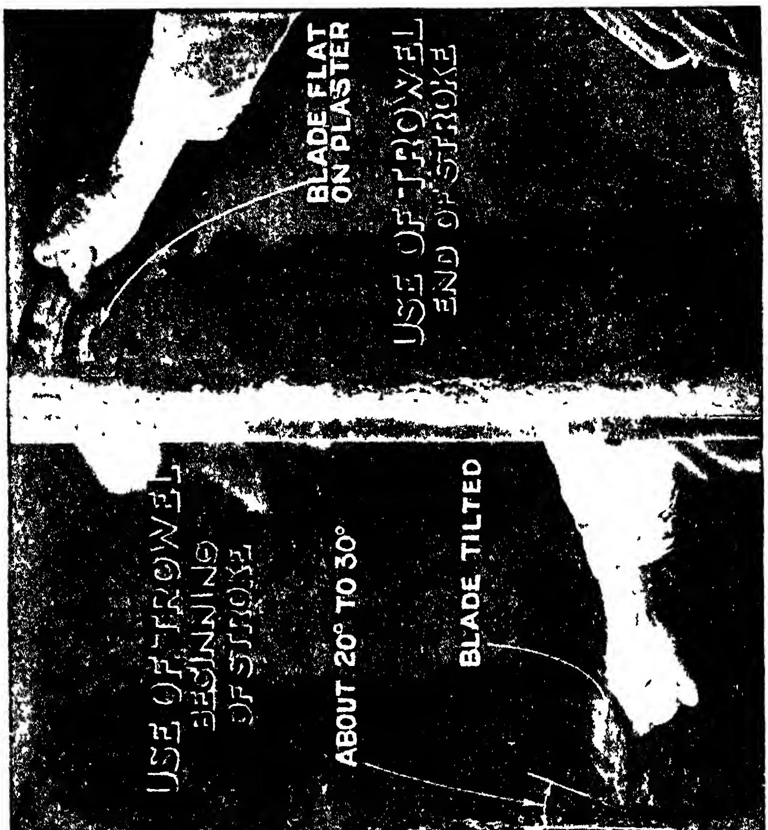


FIG. 5,506 — Use of trowel 1 ***Beginning of stroke*** showing trowel tilted, the blade is gradually turned during the stroke to its final flat position shown in fig 5,507 The amount of tilting will depend on the quantity of plaster on hand.

FIG 5,507 — ***Use of trowel.*** 2 End of stroke showing blade flat on surface of the plaster.

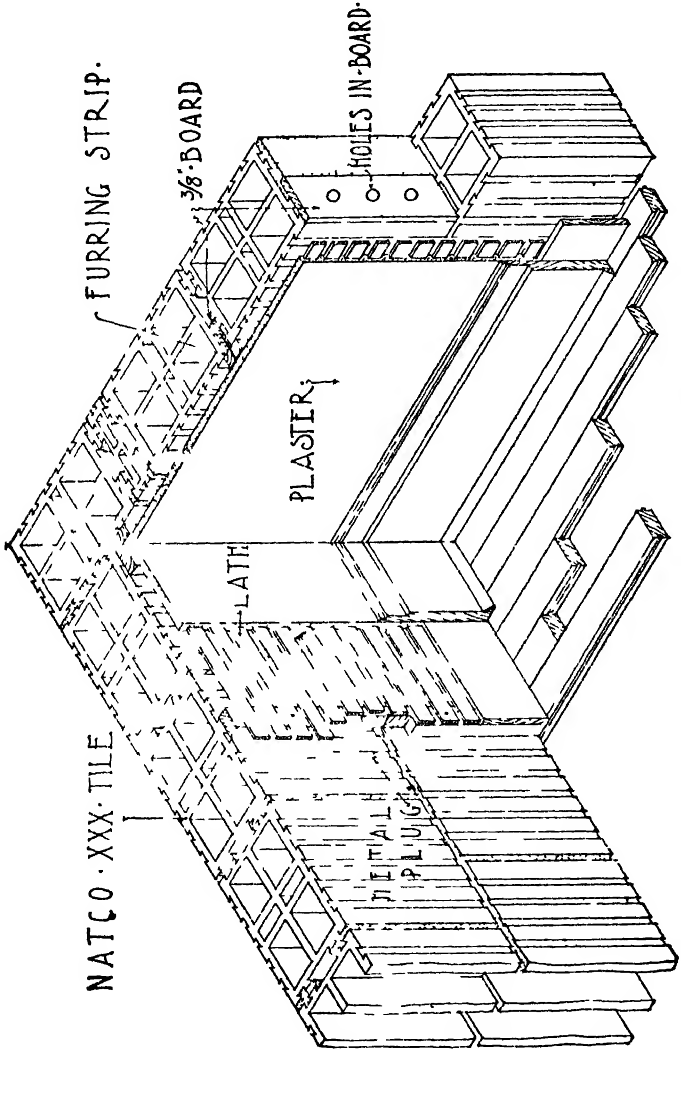


FIG 5,508 —Plastering on wooden lath attached to furring strips placed on hollow tile

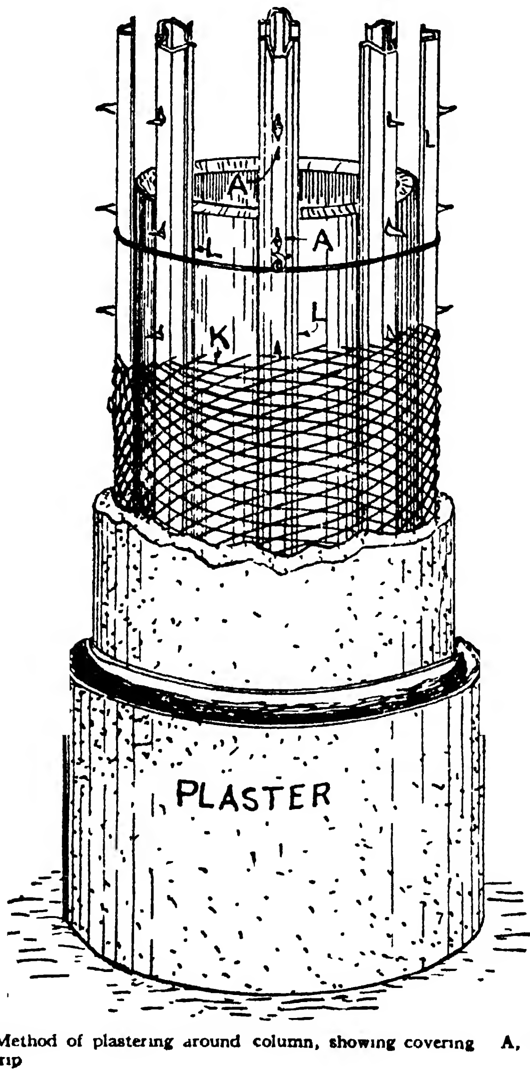


Fig. 5,509.—Method of plastering around column, showing covering A, prong, K, lath; L, furring strip

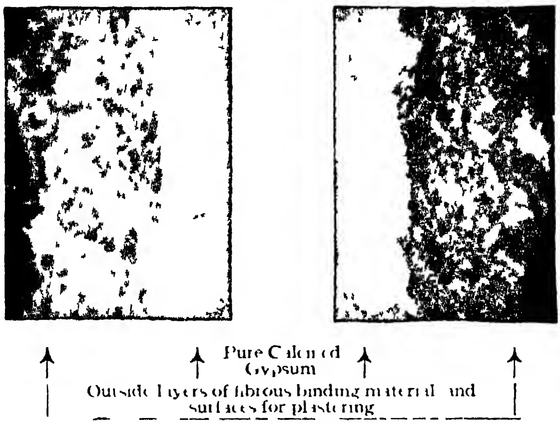
For two coat work the coats are called

1. Rendering coat. 2. Set coat

and for three coat work,

1. Rendering coat. 2. Floated coat. 3. Set coat.

Plastering on Lath.—When laying on the first coat on the



Figs. 5,510 and 5,511. Sackett board magnified 200 diameters showing impregnation of felt by gypsum. The long interwoven fibres afford the same ideal bond for the plaster as for the gypsum layer that is interposed during manufacture. Sackett board is composed of four sheets of felt alternating with three layers of gypsum. These alternate layers give the necessary flexibility, also prevent too rapid absorption during plastering. The felt has good tensile strength, does not contract, and the Sackett and plaster become one solid mass of gypsum.

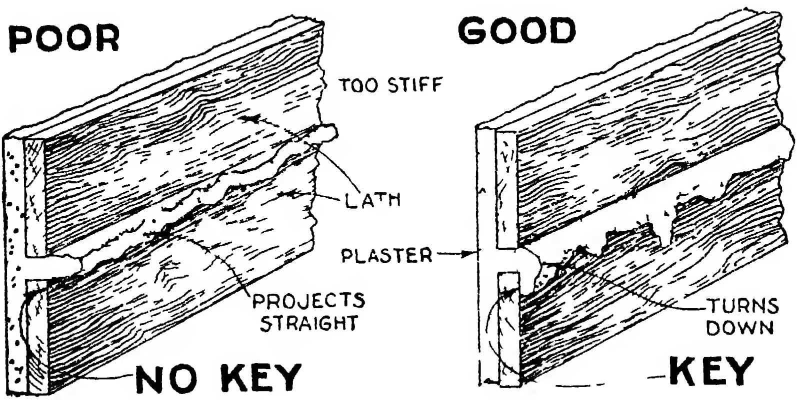
lathed surface, the hair mortar should not be too thick. It should be well mixed and of fair consistency so as to pass easily between the joints in the lathing and to bend over and behind them so as to form keys.

Figs. 5,512 and 5,513 show poor and good keying obtained by having the mortar too stiff and of the right consistency respectively. When laying on the first coat on the lathed surface the hair mortar should not be too thick, should be well mixed, and of fair consistency, so as to pass easily between the points in the lathing and to bend over and behind them but it must also be gluey enough so as not to break away. It should form a sur-

face thickness of one quarter or three eighths of an inch, so as not to be too heavy, that its own weight will cause it to break and fall inside or out.

As ceilings are lathed either with wood or wire it is usual to first plaster them, afterwards doing the walls, working gradually from the top down, but the foregoing remarks apply to both

After the first coat is entirely spread it is scored or "scratched" with an implement called a scratcher shown in fig. 5 499 The plaster should be scratched while it is soft or green so as to obtain deep grooves. Before the second or brown coat is put on the surfaces must be fitted with *screeds* which consist of straight clear strips of wood or metal



FIGS 5,512 to 5 513 Results with mortar too stiff and of right consistency The mortar should be soft enough so that when it is forced through the space between the lath, the weight of the projecting mortar will cause it to curve downward thus keying the mortar to the lath as in fig 5 51

The screeds are lined up along the edges of the ceilings and walls to form guides for the whole surfaces The surfaces are made true with the darby and straight edge and should be about 4 to 8 ft apart Every ceiling and wall must have four screeds, one for each edge or corner, the spaces between them are next filled in with brown mortar and *floated* with a float, the surface being scored down rough to make an adhering base or *matrix* for the third coat called the *white* or *finishing coat*

In no case should the second coat be put on until the "scratch" is

perfectly dry, because if only partially dry, the two coats will not stick together, but will soon come apart and the second coat will fall off. Furthermore, when the scratch coat is not sufficiently dried and only imperfectly

FIG. 5,511.—Plastering. *1st or scratch coat* showing proper method of holding trowel and hawk. Here the trowel at beginning of stroke is tilted nearly 90° because of the considerable amount of plaster on the blade.

set, it is neither hard nor tough and will not stand floating, pressing, etc., without being injured. It may become loosened from the laths, and the clinches broken so that as a natural sequence it all falls off.

FIG. 5,515.—Plastering. *1st coat scratched,* showing application of the scratcher in roughing the surface to form "keys" for holding the second coat.

FIG. 5,516.—Plastering. *2nd or brown coat,* showing method of truing the surface with darby.

When therefore the scratch coating is properly done then the next is spread leaving no hollows, nor uneven places, or "cut faces" as they are ironically termed by skilled plasterers.

Only as large a surface should be covered at one time as can be darbied, floated, etc., before it has time to set.

Some think the first screed should be put on walls at the base and the next the length of the straight edge above it, or at a convenient height to suit the workman

After browning the bottom half of the walls the scaffold may be put up and the screeds and browning done on the ceilings and upper half of the walls as many plasterers prefer this method to working downward according to convenience

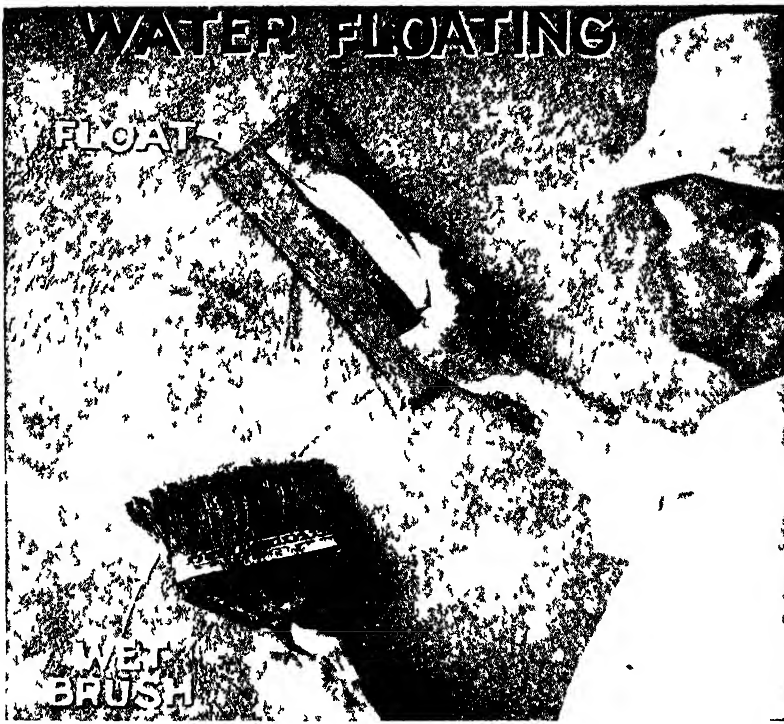


Fig. 5,517.—Plastering *Water floating.* This is done with a wet brush and float as shown

Water Floating.—This operation is performed, as in fig. 5,517, by sprinkling water on the surface and rubbing it over with the float It tends to harden the plaster and smooth it out. When it is not employed, hairs will gather along the edges of the float.

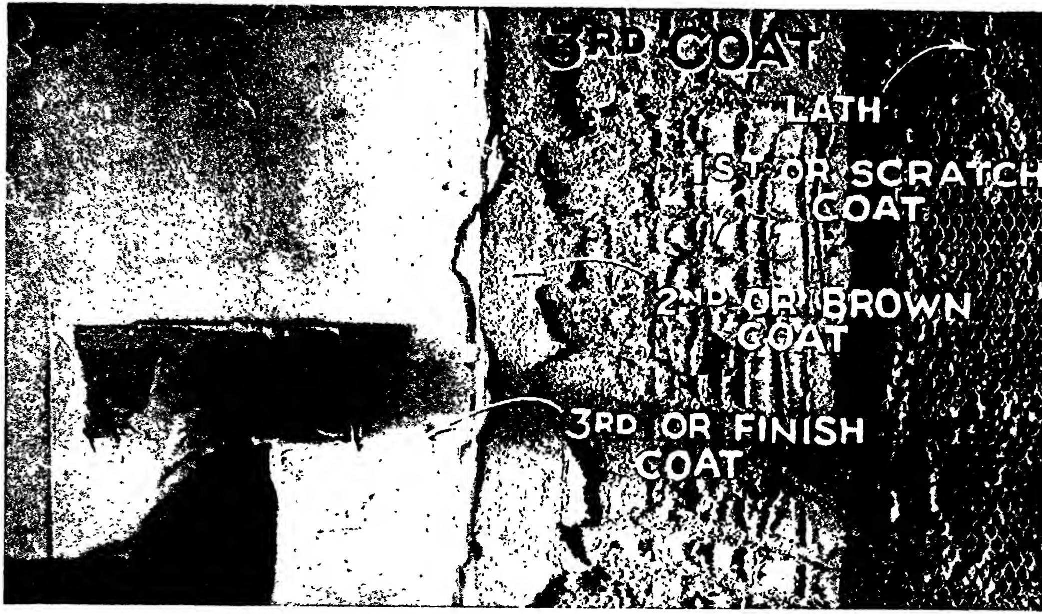


FIG. 5,518.—Plastering. ***3rd or finish coat.*** On first class work there are in fact two of these coats, skimmed on in two very thin layers.

Plaster of Paris or *gypsum* is sometimes used in the scratch coats of ceilings to make the mortar set quickly and hard. When so introduced this mineral should be gauged or mixed in with the plaster after it is placed upon the mortar board and the scratching done before the coat has set.

Finishing Coats.—These must not be spread nor laid until the brown mortar is

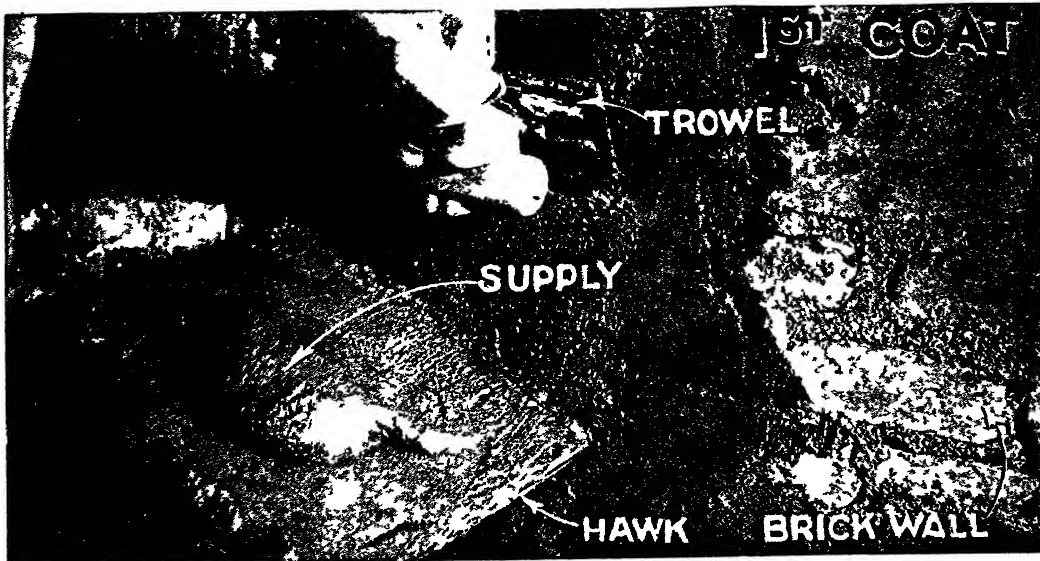


FIG 5 519 —Plastering on brick wall *1st coat* showing handling of trowel and hawk

dry and hard, because it would be likely to crack if put on sooner, besides there is always the possibility of injuring the soft brown mortar by heavy pressing or trowelling. A simple putty coat needs more sand than a hard finish and the latter should be gauged, which means it should have plaster of Paris mixed with the putty when it is placed upon the mortar board.

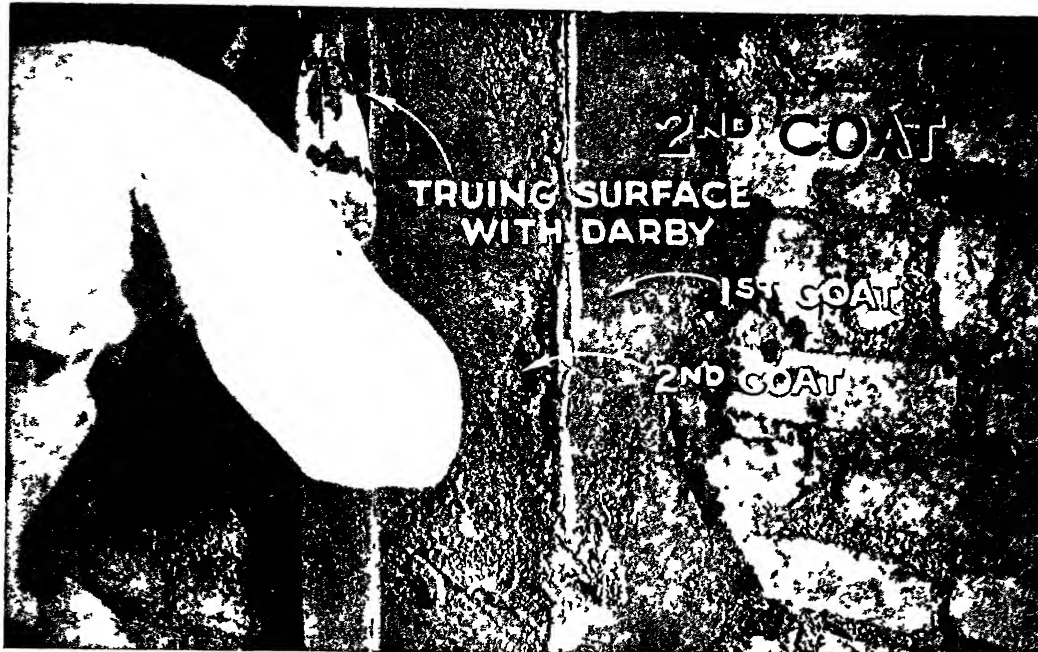


FIG 5 520 —Plastering on brick wall *2nd coat* showing handling of darby

In gauging the putty, it is usual to make a hollow with the trowel in the middle of the pile of putty large enough to hold the plaster and water about 12 or 16 inches in diameter in common practice, the putty forming a ring on the outside then water is poured in from a pail or other vessel, the plaster sprinkled into the water and the whole composition or mass mixed rapidly using the hawk in the left hand and

Fig 5 521 —Plastering on ceiling ***1st coat*** showing proper handling of hawk and trowel.

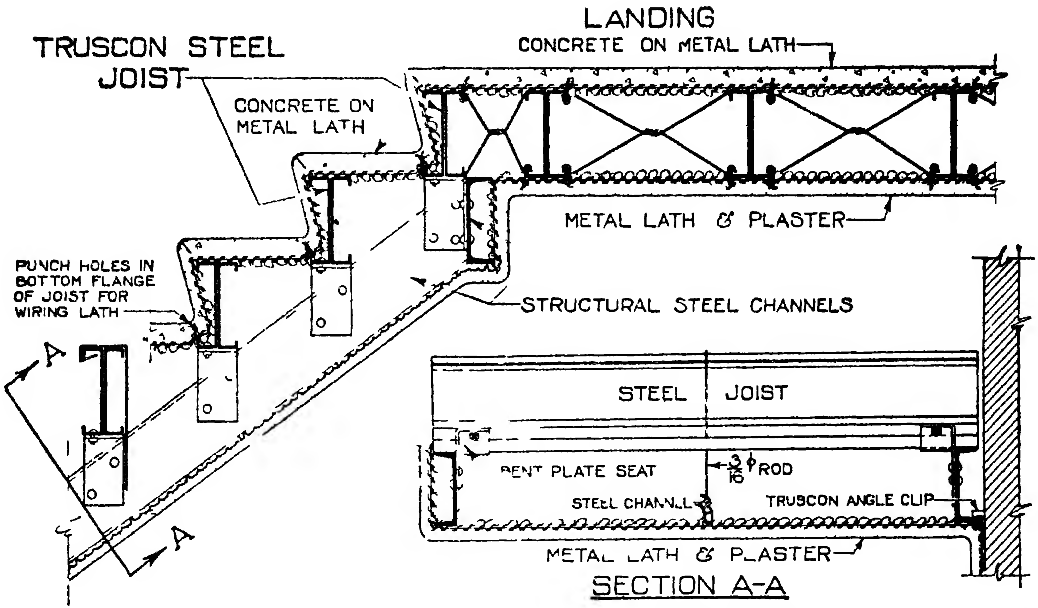


FIG 5 522 and 5 52 Truscon ... stairs shown ... construction with plaster on metal lath supporting joists are placed as close as desired ... simple in construction the angle brackets for the steel joists bring riveted onto the stringers in the fabricating plant

trowel in right The stuff when mixed to a proper workable consistency is then rapidly applied to the wall or ceiling before it has time to stiffen and set

Proportions of lime, putty and plaster vary but the average is probably one fourth or one fifth plaster of Paris

Finish or white coats are generally skimmed on in two very thin layers, one right after the other, although some plasterers skim three times after which the finish will be about 1/16" or 1/8 of an inch in thickness and it is at once troweled over several times with a wet brush and trowel to guard against chip cracking and to obtain a smooth surface

After troweling, the whole surface should be wet brushed once or twice and if a "buffed" or polished surface is to be made, it should be again brushed until a polished, glossy surface is obtained

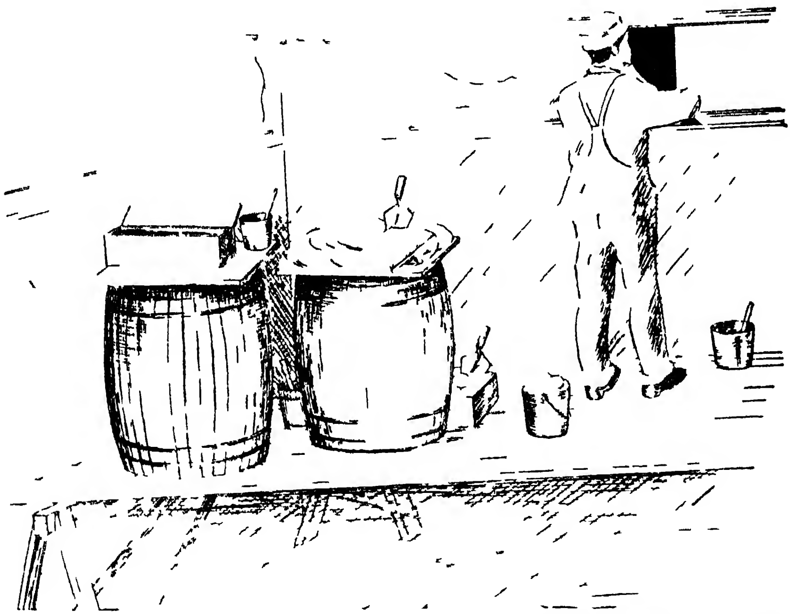


FIG. 5?1 Method of plastering moulded cornices showing mould in position and being pushed along the [illegible] of the wall

Plastering on Stone, Brick or Concrete With this class of work no scratch is used, only one coat of brown, the work being the same as second coat in dry work on lathing. Finish is as before described.

Moulded Plaster Cornices. - Place the mould at the angle

of the intersection of wall with ceiling, make a mark on the ceiling and side wall above and below the shoe at each end of the angle and "strike" a chalk line on the brown coat, by which to guide the placing of screeds. Plaster screeds are run with highly gauged mortar, straightened with the straight edge and troweled smoothly, one on the ceiling and one on the side walls at a proper distance from the angle for the shoes of the mould to slide upon.

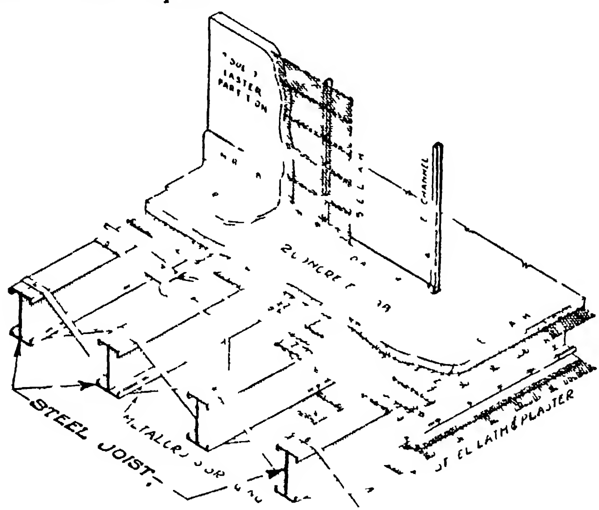


FIG. [illegible]—Truscon 2 in. solid [illegible] to joist [illegible] plaster on metal lath and channels. Wood [illegible]

When the screeds are finished, repeat the operation of placing the mould on the face of screeds at the intersection of the angles as before. Be sure that the mould is at right angle with the angles, mark shoes on the ceiling and side wall as before, and strike fine chalk line on the ceiling. Then thin wooden, longitudinal strips are attached or nailed to the side wall for a guide upon which the lower shoes of the mould slides. The ceiling guide is merely a line. Be sure to keep the shoe on the ceiling with line.

These wooden strips must be carefully adjusted, so that the mould will run in a straight line.

Moulds for linear moulding are made of some metal plates, cut in design to fit the moulding desired, and fastened to wooden backings, for the purpose of stiffening the moulds. Cornice moulds of the same description are made with shoes to slide on strips and screeds. The blade or cutting piece, can be set into the head piece at an angle of forty-five degrees, so that it will run into the angle and make the miter.

If a miter mould be not used, the miter must be filled out by hand with the mitering rod and other small tools made for that purpose, but the miter mould works much more easily and saves a great deal of time. Mitering tools are used to make miters by hand, where they cannot be easily made with the mould. They are also used to finish out breaks or balks in the

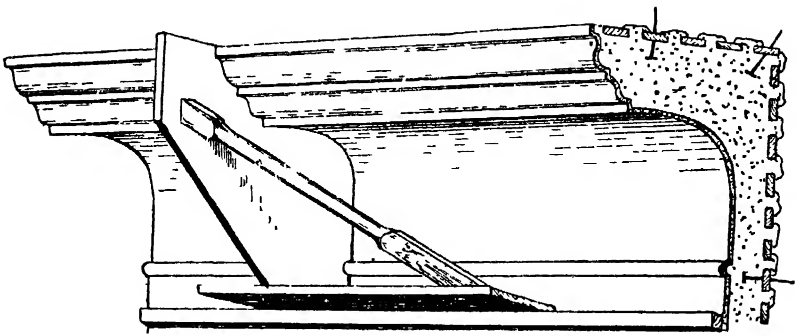


FIG. 5,526 —Detail of mould with arm and guide arranged to slide on moulding strip.

mouldings, where the mould is taken off, etc. They consist of a number of steel and wooden tools of a variety of shapes and sizes, among which is the mitering rod; this is a flat tool, about $3 \times 14 \times \frac{1}{8}$ in., with one edge sharp and one end beveled to an angle of about thirty degrees, the acute angle being at the sharp edge. The coarse stuff is made to conform to the approximate profile with a muffled mould, that is, by forming a layer of plaster of Paris along the edge of the mould about $\frac{1}{8}$ in. in thickness, or an extended profile can be cut out of most any rigid sheet metal and attached temporarily to the correct mould. The mould is placed in position and pushed along the angle of the wall, as illustrated in fig. 5,526. Some plasterers prefer to push the mould with the left hand instead of with the right, so that they can handle the trowel with the right hand when applying the stuff to make up any deficiency. Therefore, the moulds require to be made to suit the direction in which they are intended to be driven, but practice and experience have proven that it is much better to push the mould with the right

hand and arm, and after the gauging has been applied, to stuff the mould with the left, using a rubber glove or mitt to save the flesh.

Laths are generally left bare in the angles, so that the mortar will clinch or key, and should the angles have been previously scratch coated cut it out to the width of the cornice moulding.

Before the coarse ground work is applied, the keying should be reinforced by driving large nails or spikes into the walls and ceilings far enough so that the mould will pass over them as in fig. 5,526.

When the coarse mortar has been correctly run in profile the surface may be coated with gauged stuff. Enough white lime putty is gauged with about an equal part of plaster of Paris to run a strip of moulding of convenient length, say one side of an ordinary room, begining six inches or so to the right of one of the perpendicular angles, and going toward the left

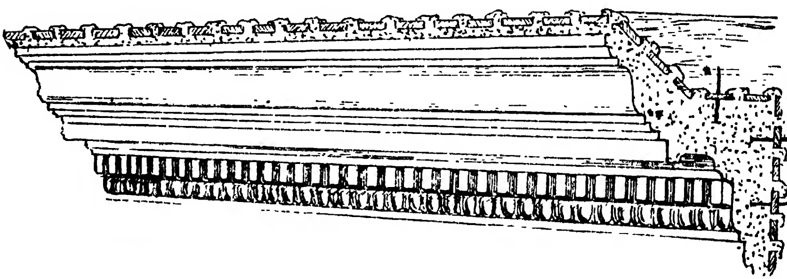


FIG. 5,527 —Projecting cornice lathed out to reduce the amount of plaster.

to within about the same distance of the next angle. Then the angle next to the ceiling, where the cornice is to be run, is filled with the soft, gauged stuff by throwing it into the angle with the trowel, until the moulding is nearly filled out or until the gauging is used up; then the mould is run over the whole length of the piece thus prepared, cutting away all the gauged stuff except the moulding. This should all be done rapidly, as the gauged stuff sets in a few minutes.

After running the mould over the first time, the gauged stuff thus scraped off with the mould should be at once used again to fill out places in the moulding where most needed, and the mold run over the moulding again. Then more stuff is gauged, and the process is repeated several times, until the moulding is filled out, after which the moulding should be sprinkled with the brush and the mould run over it once more· then go to the next piece of cornice and proceed as before.

When the cornice projects considerably, the angle must be furred or blocked, and lathed, to reduce the quantity of plaster required (see fig. 5,527), as there should be no thickness of plaster much over three inches. If the cornice is to be ornamented, recesses are left in the cornice to receive the pieces to be inserted, which are formed separately, and then stuck in with liquid plaster. When there is much ornament, it is cheaper to cast the cornice of plaster of Paris in sections two feet or more long; these may be attached to the wall by thin plaster. Careful work is required to make the moulded pieces come together or match properly, and joints must be filled and rubbed, so as to be invisible.

Measuring Plasterer's Work.—The following was published in one of the leading building journals, a few years ago, and will not be out of place here: "Plastering is always measured by the square yard for all plain work, and by the foot superficial for all cornices of plain members, and by foot lineal for enriched or carved mouldings in cornices.

"By plain work is meant straight surfaces (like ordinary walls and ceilings) without regard to the style or quality of finish put upon the job. Any panelled work, whether on walls or ceilings, run with a mould, would be rated by the foot superficial.

"Different methods of measuring plastering find favor in different portions of the country." The following general rules are believed to be equitable and just to all parties:

First.—Measure on all walls and ceilings the surface actually plastered, without deducting any grounds or any openings of less extent than seven superficial yards.

Second.—Returns of chimney breasts, pilasters and all strips of plastering less than 12 inches in width, measure as 12 inches wide; and where the plastering is finished down to the base, surbace, or wainscoting, add 6 ins. to height of walls.

Third.—In closets add one-half to the measurement. Raking ceilings and soffits of stairs, add one-half to measurement. Circular or elliptical work, charge two prices; domes or groined ceilings, three prices.

Fourth.—For each 12 ft. interior work is done further from the ground; then the first 12 ft. add five per cent. For outside work, add one per cent for each ft. the work is done, above the first 12 ft.

Stucco work is generally governed by the following rules, viz: Mouldings less than one foot girt are rated as one ft; over one ft. to be taken superficial. When work requires two moulds to run same cornice, add one-fifth. For each internal angle or mitre, add one ft. to length of cornice; and for each external angle, add two ft. All small sections of cornice less than 12 ins. long measure as 12 ins. For taking cornices, add one-half. Circular or elliptical work, double price; domes and groins, three prices. For enrichments of all kinds, a special price must be charged. The higher the work is above ground, the higher the charge must be; add at the rate of five per cent, for every 12 ft. above the first 12 ft

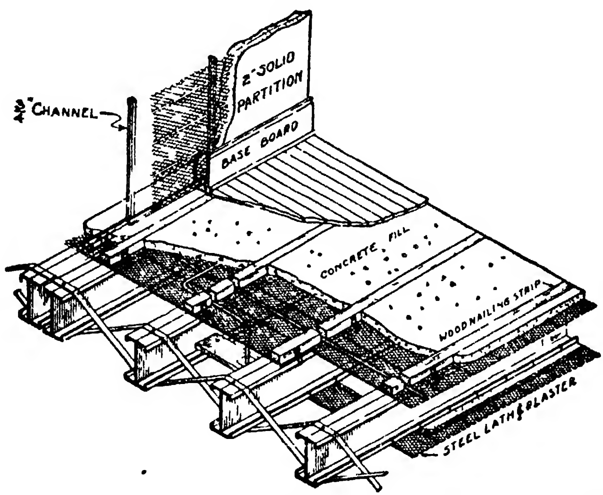


FIG 5,528 —Truscon 2 in solid non bearing partition parallel to joists, plaster on metal lath and channels Wood floor finish

NOTE —*All joining* must be worked over until they are "out" or invisible Angles may be finished with the wooden paddle because in rapid work the trowel may cut into the angles

NOTE —*In finishing* or white coat work ceilings should be done first then the upper parts of walls and finally bottoms Often walls are finished top and bottom at the same time and in theatres, halls, and where the ceilings are very high in rooms, several mechanics work together on horse scaffolds, 6 feet in height, one above the other, thus avoiding joints in the work and giving continuous surfaces

NOTE —*All plastering in damp places* should be done with Portland cement mortar the mortar being worked rapidly.

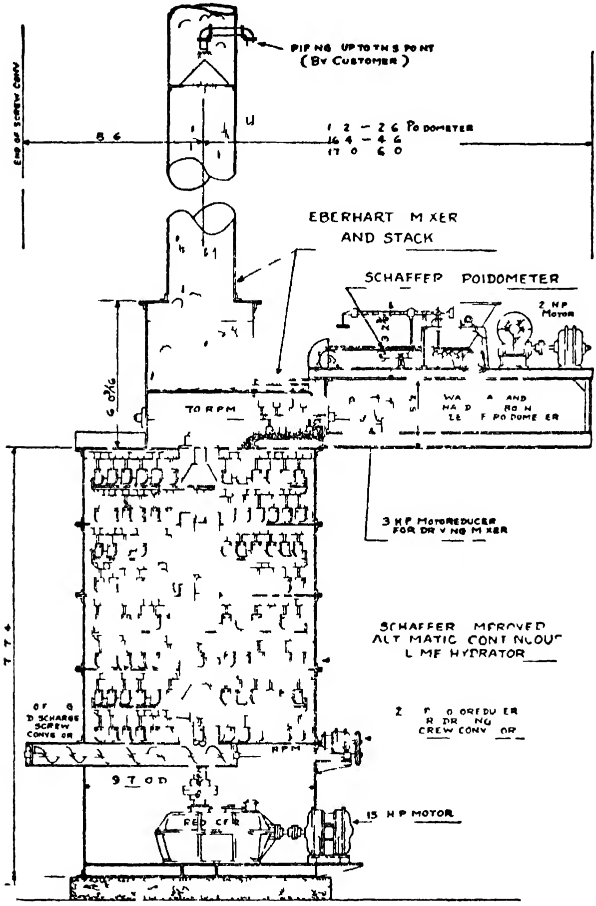


Fig. 5,528A —Showing a Schaffer continuous type *lime hydrator*. Hydrated lime is a dry powdered material resulting from the ... of quicklime with just enough water to satisfy the reaction. The hydration process is most commonly accomplished by special hydrators at the mill. The machine illustrated is of the vertical cylinder type with a series of pans. Some of the pans revolve and have stationary plows in them, whereas others have pans which are stationary with the plows revolving in them. Quicklime crushed to ¼ in. and smaller is accurately weighed and delivered to a mixer located on the top of the hydrator by a poidometer. All the water used for hydration is introduced at a point near the top of the stack, the amount being regulated by a needle valve in correct proportion to the type of quicklime to be hydrated.

Plasterers' Automatic Wall Measurement Tables

Showing Total Number of Square Yards in Rooms of Various Sizes. To be used in figuring amount of plaster required for given areas. Directions for Use

Example: To obtain the number of square yards in a room 15x14x7 6 Turn to the table giving measurement of rooms with 7.6-foot ceilings, follow down the column of figures on the left until you come to 15, then follow the figures to the right until you come to the figures directly under the figure 14 at the top of the page the answer is 71 6 square yards When the half-foot comes in the dimensions of a room, both ways take the next largest number on one side When it comes on one side only, add one yard and it will be close

Number of Square Yards and Feet in Rooms with 7 6-foot Ceilings

	3	4	5	6	7	8	9	10	11	12	13	14	15	16
3	11 0	13 0	15 0	17 0	19 0	21 0	23 0	25 0	27 0	29 0	31 0	33 0	35 0	37 0
4	13 0	15 1	17 2	19 3	21 4	23 5	25 6	27 7	29 8	2 0	34 1	36 2	38 3	40 4
5	15 0	17 2	19 4	21 6	23 8	26 1	28 3	30 5	32 7	35 0	37 2	39 4	41 6	43 8
6	17 0	19 3	21 6	24 0	26 3	28 6	31 0	33 3	35 6	38 0	40	42 6	45 0	47 3
7	19 0	21 4	23 8	26 3	28 7	31 2	33 6	36 1	38 5	41 0	43 4	45 8	48 3	50 7
8	21 0	23 5	26 1	28 6	31 2	33 7	36 3	38 8	41 4	44 0	46 5	49 1	51 6	54 2
9	23 0	25 6	28 3	31 0	33 6	36 3	39 0	41 6	44 3	47 0	49 6	52 3	55 0	57 6
10	25 0	27 7	30 5	3 3	36 1	38 8	41 6	44 4	47 2	50 0	52 7	55 5	58 3	61 1
11	27 0	29 8	[illegible]	[illegible]	5 5	41 4	41 3	47 2	50 1	53 0	55 8	58 7	61 6	64 5
12	29 0	32 0	5 [illegible]	8 0	41 0	44 0	47 0	50 0	53 0	56 0	59 0	62 0	65 0	68 0
13	31 0	34 1	37 [illegible]	40 [illegible]	43 1	46 5	49 6	52 7	55 8	59 0	62 1	65 2	[illegible]	71 4
14	33 0	36 [illegible]	9 4	42 6	45 8	49 1	52 3	55 5	58 7	62 0	65 2	68 4	71 6	74 8
15	35 0	38 3	41 6	45 [illegible]	48 3	51 6	55 0	58 3	61 6	65 0	68 3	71 6	75 0	78 3
16	7 [illegible]	40 4	43 8	47	50 7	54 2	57 6	61 1	[illegible]	68 0	71 4	74 8	78 3	81 7
17	39 0	42 5	46 1	49 [illegible]	3	56 7	60 3	63 8	67 4	71 0	74 [illegible]	78 1	81 6	85 2
18	41 0	44 6	48 [illegible]	52 0	55 6	59 3	63 0	66 6	70 3	74 0	77 6	81 2	85 0	88 6
20	45 0	49 8	52 7	56 [illegible]	0 5	64 4	68 3	72 2	76 1	80 0	84 8	87 7	91 6	95 5
21	47 0	51 0	55 0	59 0	63 0	67 [illegible]	71 0	75 0	79 [illegible]	83 0	87 0	91 0	95 0	99 0
22	49 0	53 1	57 2	61 3	65 4	69 5	73 6	77 7	81 8	86 0	90 1	94 2	98 3	102 4
24	53 0	57 3	61 6	66 0	0 3	74 6	79 3	83 3	87 7	92 0	96 3	100 7	105 0	109 3

The amount indicated includes side walls and ceilings

Number of Square Yards and Feet in Rooms with 8-foot Ceilings

	3	4	5	6	7	8	9	10	11	12	13	14	15	16
3	11 6	13 7	15 8	18 0	20 1	2 2	24 3	26 4	28 5	30 6	32 7	34 8	37 0	39 1
4	13 7	16 0	18 2	20 4	22 6	4 8	27 1	29 3	31 5	33 7	36 0	38 2	40 4	42 6
5	15 8	18 2	20 5	22 8	[illegible]	27 5	29 8	32 2	34 5	36 8	39 2	41 5	43 8	46 2
6	18 0	20 4	22 8	25 3	27 7	30 2	32 6	35 1	37 5	40 0	42 4	44 8	47 3	49 7
7	20 1	22 6	25 2	27 7	30 3	32 8	5 4	38 0	40 5	1 1	45 6	48 2	50 7	53 3
8	22 2	24 8	27 5	30 2	32 8	35 5	38 2	40 8	43 5	46 2	48 8	51 5	54 2	56 8
9	24 3	27 1	29 8	32 6	35 4	38 2	41 0	43 7	46 5	49 3	52 1	54 8	57 6	60 4
10	26 4	29 3	32 2	35 1	38 0	40 8	43 7	46 6	49 5	52 4	55	58 2	61 1	64 0
11	28 5	31 5	34 5	37 5	40 5	43 5	46 5	49 5	52 5	55 5	58 5	61 5	64 5	67 5
12	30 6	33 7	36 8	40 0	43 1	46 2	49 3	52 4	55 5	58 6	61 7	64 8	68 0	71 1
13	32 7	36 0	39 2	42 4	45 6	48 8	52 1	55 3	58 5	61 7	65 0	68 2	71 4	73 6
14	34 8	38 2	41 5	44 8	48 2	51 5	54 8	58 2	61 5	64 8	68 2	71 5	74 8	78 2
15	37 0	40 4	43 8	47 3	50 7	54 2	57 6	61 1	64 5	68 0	71 4	74 8	78 3	81 7
16	39 1	42 6	46 2	49 7	53 3	56 8	60 4	64 0	67 5	71 1	74 6	78 2	81 7	85 3
17	41 2	44 8	48 5	52 5	55 8	59 5	63 2	66 8	70 5	74 2	77 8	81 5	85 2	88 8
18	43 3	47 1	50 8	54 6	58 4	62 2	66 0	69 7	73 5	77 3	81 1	84 8	88 6	92 4
20	47 5	51 5	55 5	59 5	63 5	67 5	71 5	75 5	79 5	83 5	87 5	91 5	95 5	99 5
21	49 6	53 7	57 8	62 0	66 1	70 2	74 3	78 4	82 5	86 6	90 7	94 8	99 0	103 1
22.	51 7	56 0	60 2	64 4	68 8	72 8	77 1	81 3	85 6	89 7	94 0	98 2	102 4	106 6
24	56 0	60 4	64 8	69 3	73 7	78 2	82 6	87 1	91 5	96 0	100 4	104 8	109 3	113 7

The amount indicated includes side walls and ceilings

Number of Square Yards and Feet in Rooms with 9-foot Ceilings

	3	4	5	6	7	8	9	10	11	12	13	14	15	16
3	13 0	15 3	17 6	20 0	22 3	24 6	27 0	29 3	31 6	34 0	36 3	38 6	41 0	43 3
4	15 3	17 7	20 2	22 6	25 1	27 5	30 0	32 4	34 8	37 3	39 7	42 2	44 6	47 1
5	17 6	20 2	22 7	25 3	27 8	30 4	33 0	35 5	38 1	40 6	43 2	45 7	48 3	50 8
6	20 0	22 6	25 3	28 0	30 6	33 3	36 0	38 6	41 3	44 0	46 6	49 3	52 0	54 6
7	22 3	25 1	27 8	30 6	33 4	36 2	39 0	41 7	44 5	47 3	50 1	52 8	55 6	58 4
8	24 6	27 5	30 4	33 3	36 2	39 1	42 0	44 8	47 7	50 6	53 5	56 4	59 3	62 2
9	27 0	30 0	33 0	36 0	39 0	42 0	45 0	48 0	51 0	54 0	57 0	60 0	63 0	66 0
10	29 3	32 4	35 5	38 6	41 7	44 8	48 0	52 0	54 2	57 3	60 4	63 5	66 6	69 7
11	31 6	34 8	38 1	41 3	44 5	47 7	51 0	54 2	57 4	60 6	63 8	67 1	70 3	73 5
12	34 0	37 3	40 6	44 0	47 3	50 6	54 0	57 3	60 6	64 0	67 3	70 6	74 0	77 3
13	36 3	39 7	43 2	46 6	50 1	53 5	57 0	60 4	63 8	67 3	70 7	74 2	77 6	81 1
14	38 6	42 2	45 7	49 3	52 8	56 4	60 0	63 5	67 1	70 6	74 2	77 7	81 3	84 8
15	41 0	44 6	48 3	52 0	55 6	59 3	63 0	66 6	70 3	74 0	77 6	81 3	85 0	88 6
16	43 3	47 1	50 8	54 6	58 4	62 2	66 0	69 7	73 5	77 3	81 1	84 8	88 6	92 4
18	48 0	52 0	56 0	60 0	64 0	68 0	72 0	76 0	80 0	84 0	88 0	92 0	96 0	100 0
20	52 6	58 [illegible]	61 1	65 3	69 5	73 7	78 0	82 2	86 4	90 [illegible]	94 8	99 1	103 3	107 5

The amount indicated includes side walls and ceilings

Number of Square Yards and Feet in Rooms with 10-foot Ceilings

	3	4	5	6	7	8	9	10	11	12	13	14	15	16
3	14 3	16 8	19 4	22 0	24 [illegible]	[illegible]7 1	[illegible]9 6	32 [illegible]	34 7	37 3	39 8	42 4	45 0	47 5
4	16 8	[illegible] 5	22 [illegible]	[illegible] 8	[illegible]	[illegible] 2	[illegible]2 8	[illegible] 5	38 2	40 8	43 5	4[illegible] 2	48 8	51 5
5	19 4	22 2	25 0	27 7	[illegible]0 5	[illegible] 3	[illegible] 1	38 5	41 6	44 4	47 2	50 0	52 7	55 5
6	22 0	[illegible]4 8	27 7	30 6	33 5	36 4	3[illegible] 3	42 2	45 1	48 0	50 8	53 7	56 6	59 5
7	24 5	[illegible]7 5	[illegible]	[illegible]	[illegible]	39 5	42 5	45 5	48 5	51 5	54 5	57 5	60 5	63 5
8	27 1	30 2	33 3	36 4	39 5	42 6	45 7	48 8	52 0	55 1	58 2	61 3	64 4	67 5
9	29 [illegible]	32 8	[illegible]6 1	39 3	42 5	45 7	[illegible]9 0	52 2	[illegible] 4	[illegible]8 6	61 8	65 1	68 3	71 5
10	32 [illegible]	3[illegible] 5	35 8	42 2	45 5	48 8	[illegible]2 2	[illegible]5 5	59 8	[illegible]2 [illegible]	[illegible] 5	68 [illegible]	72 2	75 5
11	34 7	[illegible]8 2	41 6	45 1	45 5	52 0	55 4	[illegible]8 9	62 3	[illegible] 7	69 2	72 6	70 1	79 5
12	37 3	40 8	44 4	48 0	51 5	55 1	58 6	62 2	6[illegible] 7	69 [illegible]	72 6	76 4	80 0	83 5
13	39 8	43 5	47 2	50 8	54 5	58 2	61 8	65 5	69 2	72 9	76 [illegible]	80 2	83 8	87 5
14	42 1	46 [illegible]	50 0	53 7	57 5	61 [illegible]	65 1	68 8	72 6	76 4	80 2	84 0	87 7	91 5
15	45 0	48 8	52 7	56 6	60 5	64 4	69 3	72 2	76 1	80 0	83 8	87 7	91 6	95 5
16	47 5	51 5	55 5	59 5	63 5	67 5	71 5	75 5	79 5	83 5	87 5	91 5	95 5	99 5
17	50 1	54 2	58 3	62 4	66 5	70 6	74 7	78 8	83 0	87 1	91 2	9[illegible] 3	99 4	103 5
18	52 6	56 8	61 1	65 3	69 [illegible]	73 7	78 0	82 2	86 4	90 6	94 8	9[illegible] 1	103 3	107 5
20	57 7	[illegible]2 2	66 6	71 1	75 [illegible]	[illegible] 0	[illegible]4 4	[illegible]8 8	93 3	97 7	1[illegible]	10[illegible] 6	111 1	115 5

The amount indicated includes side walls and ceilings

Number of Square Yards and Feet in Rooms with 12-foot Ceilings

	3	4	5	6	7	8	9	10	11	12	13	14	15	16
3	17 [illegible]	20 0	23 0	26 0	29 0	32 0	35 0	38 0	41 0	44 0	47 0	50 0	53 0	56 0
4	20 0	[illegible] 1	[illegible] 2	2[illegible] 3	3[illegible] 4	[illegible] 5	38 6	41 7	44 8	48 0	51 1	54 2	57 3	60 4
5	23 0	[illegible] 2	29 4	32 [illegible]	35 8	39 1	42 3	45 5	48 7	52 0	5[illegible] 2	58 4	61 6	64 8
6	26 0	2[illegible] [illegible]	32 6	[illegible] 0	39 3	42 6	46 0	49 3	52 6	56 0	59 [illegible]	62 6	66 0	63 3
7	2[illegible] 0	[illegible]2 4	35 8	39 3	42 7	46 2	49 6	53 1	56 5	60 0	63 4	66 8	70 3	73 7
8	32 0	35 5	39 1	42 [illegible]	46 2	49 7	53 3	56 8	60 4	61 0	67 5	71 1	74 6	78 2
9	35 0	[illegible]8 6	42 3	46 0	49 0	53 3	57 0	60 6	64 3	6[illegible] 0	71 6	75 3	79 0	82 6
10	38 0	41 7	45 5	49 3	53 0	56 8	60 6	64 4	68 2	72 0	75 7	79 5	83 3	87 1
11	41 0	41 8	48 7	52 [illegible]	[illegible]6 5	60 4	64 [illegible]	68 2	72 1	76 0	79 8	83 7	87 6	91 5
12	44 0	48 0	52 0	56 0	60 0	64 0	68 0	72 0	76 0	80 0	84 0	88 0	92 0	96 0
13	47 0	51 1	55 2	59 3	63 4	67 5	71 6	75 7	79 8	81 0	85 1	92 2	96 3	100 4
14	50 0	54 2	58 4	62 6	66 8	71 1	75 3	79 5	83 7	88 0	92 2	96 4	100 6	104 8
15	53 0	57 3	61 6	66 0	70 3	74 6	79 0	83 3	87 6	92 0	96 3	100 6	105 0	109 3
16	56 0	60 4	64 8	69 3	73 7	78 2	92 6	87 1	91 5	96 0	100 4	104 8	109 3	113 7
17	59 0	63 5	68 1	72 6	77 2	81 7	86 3	90 8	95 4	100 0	104 5	109 1	113 6	118 2
18	62 0	66 6	71 3	76 0	80 6	85 3	90 0	94 6	99 3	104 0	108 6	113 3	118 0	122 6
20	68 0	72 8	77 7	82 6	87 5	92 4	97 3	102 2	107 1	112 0	116 8	121 7	126 6	131 5

The amount indicated includes side walls and ceilings

NOTE —*Alca Lime.* A recent development in the lime industry is Alca lime. This is a material said to combine the plasticity and sand carrying qualities of lime mortar with the strength, hardness and quicker set of the gypsum plasters. It is composed of approximately 85% of hydrated lime and 15% of a specially prepared material containing alumina and silica in such proportions as to combine, forming bodies which greatly contribute to the strength, hardness and plasticity of the product. It is sold in 100 lb. packages and requires only to be mixed with sand and water before use. When used for plastering, it has the characteristics of lime mortar, and while it becomes hard and strong, it is claimed that it is free from the so called sounding board effects noticed in some hard wall plasters. It is not injured by water and is often used for outside stucco work and also as a brick laying mortar in place of lime mortar gauged with Portland cement. The manufacturers directions for the use of Alca lime should be carefully observed, and this may be said of all prepared plastering or cementing materials.

NOTE — *Useful data on quicklime.* Quicklime is shipped either in barrels or in bulk. In dry climates it will keep for a long time in bulk, but in damp climates and along the coast, it soon slakes unless enclosed in barrels. By Act of Congress, August 23, 1916, it is required that lime in barrels shall be packed only in barrels containing 280 lb. or 180 lbs. net weight. When shipped in bulk it is generally sold by the bushel of 80 lb., 3½ bushels or 280 lbs. net of lime being considered as equivalent to a large barrel. Other weights are 180 lb. net per small barrel, and 64 lbs. net per cu. ft. The average yield of lime paste from the best Eastern limes has been found to be 2.62 times the bulk of unslaked lime. A barrel of good quality well burned lime should make 8 cu. ft. or 20 pails or lime paste or putty. Careful experiments conducted by United States engineers have demonstrated that the best mortar is obtained by mixing one part of lime paste to two parts of sand.

NOTE —*Hydrated Lime.* The slaking of quick lime is an operation which is almost invariably carried on by laborers who have little or no conception of the importance of their task. As a result, many failures have been charged to lime in the past which actually were due to improper preparation during the slaking operation. The new product known as *hydrated lime* has been offered widely to the trade in recent years and has met with much success. Hydrated lime is a dry flocculent powder resulting from the slaking of quick lime by mechanical means with an amount of water which is sufficient to satisfy the calcium oxide, but insufficient to make a paste or putty. Hydrated lime is manufactured in mechanical hydrators in which the batches of quick lime and water used are carefully proportioned by weight. After passing from hydrator hydrated lime is subjected to a mechanical system of separation which eliminates the coarse or impure particles which may cause popping, etc. Hydrated lime is sold in bags of definite weight and requires only to be mixed with sand and water to make the mortar. The bags have usually been made of heavy burlap or duck cloth, containing 100 lb. or of paper containing 40 lb. Several of the more prominent manufacturers of hydrated lime in the United States employ chemists who regularly superintend the manufacture of hydrated lime, just as the chemists in Portland cement factories superintend the proportioning of the raw mix going to the kilns to be burned for Portland cement. The hydrated lime manufactured under such chemical supervision is a reliable product free from tendencies which might give rise to popping, pitting or disintegration. Hydrated lime of good quality may be used for almost any purpose for which lime water is used and is by some considered a more reliable product than quicklime. Among the newer uses for hydrated lime may be mentioned its employment in cement mortars and concrete. An addition of about 10% of hydrated lime to cement mortar or concrete decreases its its permeability to water, reduces the cracking due to shrinkage, etc. and increases the plasticity of the mortar or concrete, thus preventing separation of the sand, stone and cement and causing the mixture to flow and fill the forms more readily.

CHAPTER 99

Stone Masonry

Stone.—The earth's crust is composed largely of rock or stone formation from which many varieties of building stone are quarried. The stones used in building are divided with respect to the principal mineral which forms the chief constituent, into three classes:

1. Siliceous stones.
2. Calcareous stones.
3. Argillaceous.

Siliceous stones are those containing silica such as granite, gneiss, trap, etc. Calcareous stones are represented by limestones and marbles. The word argillous is defined as *consisting of, containing, or like clay.* Argillous stones are represented by clay, porphyry, slate, etc.

Building Stone Requirements.—Evidently for building purposes, a good building stone should possess strength, durability, cheapness and fine appearance. The durability will depend upon the chemical composition, physical structure, and the position in which the stone is placed in the work. The same stone will vary greatly in its durability according to the nature and extent of the atmospheric influences to which it is subjected. The strength of a stone under compression and cross

strain is an important factor for the weight of the masonry and floor loads must be supported, resulting in considerable pressure on the lower courses. Evidently for a given load the lower the compressive strength of the stone, the thicker the wall for safe loading.

In regard to appearance, all stones containing much iron should not be used, because they are liable to disfigurement from rust stains, caused by the oxidation of the iron under the influence of the atmosphere.

Selection of Stone.—The chief factor in the choice of a building stone should be the climate to which the stone has to be exposed. Thus, stone that in pure country air has proved extremely durable may quickly decay in an impure city atmosphere or when subjected to the strong salt winds from the sea.

The sulphur acids, carbonic acid, hydrochloric acid and traces of nitric acid, in the smoky air of cities and towns, and the carbonic acid in the atmosphere ultimately decompose any stone of which either carbonate of lime or carbonate of magnesia forms a considerable part. Wind has a considerable effect upon the durability of stone. High winds blow sharp particles against the face of the stone and thus grind it away. Moreover, it forces the rain into the pores of the stone, and may thus cause a considerable depth to be subject to the effects of acids and frost. In winter water penetrates porous stones, freezes, expands and disintegrates the surface, leaving a fresh surface to be similarly acted upon.

Further, extremes of temperature usually shorten the life of stone, the alterations of heat and cold setting up movements in the substances to the stone, which though slight, will in many cases hasten its disintegration. There are few materials

which more quickly decay and fail than stone placed under unsuitable conditions. In the selection of stones for building purposes the following characteristics of the stones generally used should be noted.

Limestones consist chiefly of calcium carbonate with small proportions of other substances. They are often classified under four heads: Compact limestones consist of carbonate of lime, either pure or in combination with clay and sand. Granular or oolitic limestones consist of grains of carbonate of lime cemented together by the same substance or mixed with sand and clay. The grains are egg shaped (hence the name "oolite") and vary in size from tiny particles to grains as large as peas. Shelly limestones consist almost entirely of small shells, cemented together by carbonate of lime. Magnesian limestones are composed of carbonates of lime and magnesia in varying proportions, and usually also contain small quantities of silica. iron and alumina. The hardest and closest grained of these are capable of taking a fine polish. Limestones should be used with care as they are uncertain in their behavior and usually more difficult to work than sandstones, and as a general rule they do not stand the action of fire well.

Sandstones are composed of grains of sand held together by a cementing substance to form a compact rock. The cementing medium may be silica, alumina, carbonate of lime or an oxide of iron. Those stones that have a siliceous cement are the most durable. Sandstones vary more in color than limestones, the color being largely due to the presence of iron. Cream, brown, grey, pink, red, light and dark blue and drab are common colors. The texture of sandstones varies from a fine, almost microscopical grain to one composed of large particles of sand. It will generally be found that the heaviest, densest, least porous and most lasting stones are those with a fine grain.

Granites are igneous rocks formed by volcanic action and are of all geological ages. Granite is composed of quartz, felspar and mica intimately compacted in varying proportions to form a hard granular stone. Quartz is the principal constituent and imparts to the rock the qualities of durability and strength. Stones containing a large proportion of quartz are hard and difficult to work. Felspar of an earthly nature is opaque in appearance and is liable to decay; it should be clear and almost transparent. The characteristic color of the granite is generally due to this substance, but the stone is often affected by the nature of the mica it contains, whether it be light or dark in tint. Granite is the hardest, strongest and most durable of building stones, and is difficult and costly to work. When polished, many varieties present a beautiful and lasting surface. By reason of its strength

and toughness this stone is often used for foundations, bases, columns, curbs and paving, and in all positions where great strength is required

Slate used for roofing and other purposes in building is a fine grained and compact rock composed of sandy clay which has been more or less metamorphosed by the action of heat and tremendous pressure Such rocks were originally deposited in the form of sediment by the sea or river, afterward becoming compacted by the continual heaping up of superincumbent material Owing no doubt to some sliding motion having at some time taken place, slatey rocks are capable of being split into thin sheets which are trimmed to the various marketable sizes A good slate is hard, tough and

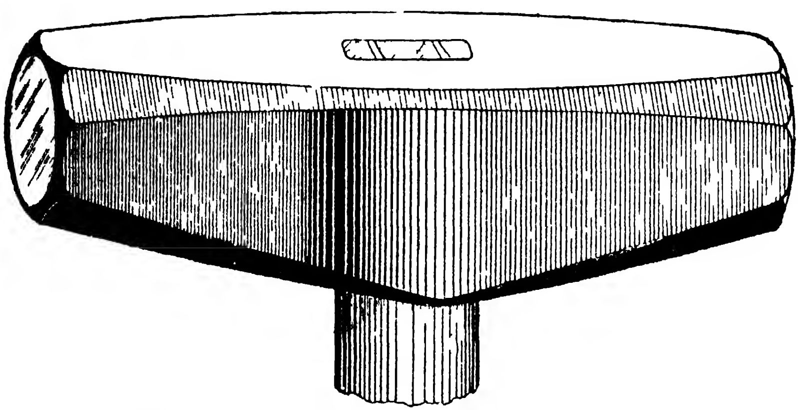


FIG 5 529 —Double face hammer *Used* only for the roughest work of roughly shaping stones as they come from the quarry and for knocking off projection *Weight*, 20 to 30 lbs

non absorbent will give out a metallic ring if struck, and when trimmed it will not splinter nor will the edges become ragged Slates range in color from purple to grey and green

Strength of Stone.—In general practice the load placed upon stone should not exceed one tenth the crushing weight as found by testing typical specimens, that is, stone walls, or other stone structures should be designed for a factor of safety of 10. The resistance to crushing or compression strength of stone varies to an enormous extent for various stones, from

a little over 60 tons per sq. ft. which is the limit for a weak limestone, up to 1,300 tons for the hardest granites.

The following table gives average data for building stones of good quality.

Properties of Stone

(Average values according to R P. Miller)

Kind of Stone	Weight lbs per cu ft	Crushing strength lbs. per sq in	Shearing strength lbs. per sq. in.
Sandstone	150	8,000	1,500
Granite	170	15,000	2,000
Limestone	170	6,000	1,000
Marble	170	10,000	1,400
Slate	175	15,000	
Trap Rock	185	20,000	

In using the table it should be understood that the strength of any particular stone varies considerably for different localities, thus limestone from Salem, Ind , has a crushing strength of only 8,625 lbs. per sq. in., while that quarried at Red Wing, Minn , has a crushing strength of 23,000 lbs , hence, caution should be exercised in using tables. When stones are not tested Frye recommends the following average values for crushing strength: Sandstone 5,000, granite and gneiss 12,000; limestones and marbles 8,000 lbs. per sq in. The planes of cleavage in most stones is in one direction mainly parallel to the natural bed and this is the position in which it is set in construction to obtain the greatest degree of strength.

The following working unit stresses in lbs. per sq. in. for stone slabs or single blocks of stone are recommended by W. J. Douglass.

Sandstone, compression, 700; tension (direct and flexual), 75; shear, 150. Granite, syenite and gneiss: compression for hard, 1,500; for medium, 1,200; for soft, 1,000; tension (direct and flexural) 150; shear, 200. Limestone: compression for hard, 1,000; tension (direct and flexural), 150; shear,

200. Limestone: compression for hard, 1,000; for medium, 800; for soft, 700; tension (direct and flexural), 125; shear, 150. Marble: compression for hard, 900; for soft, 700. Tension (direct and flexural), 125; shear, 150. Bluestone flagging: compression, 1,500; tension (direct and flexural), 200.

Stone Cutting Tools.—Both hand and machine tools are used in shaping the stones to the desired form. The hand tools may be classified according to their use as

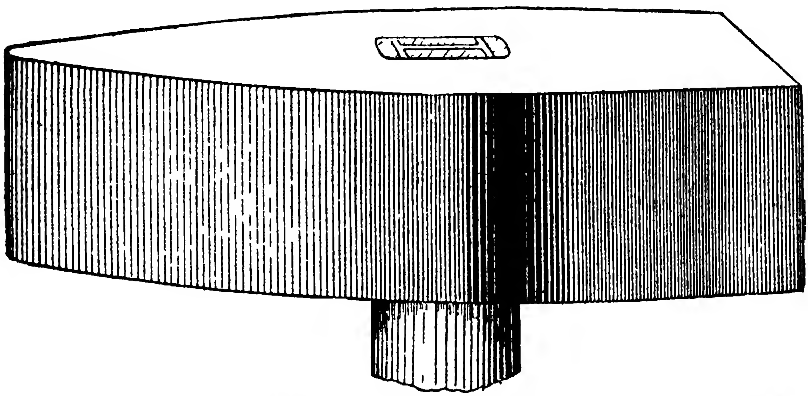


FIG 5,530 —Face hammer *Used* for the same purpose as the double face hammer where less weight is required The cutting end is used for roughly squaring stones preparatory to the use of the finer tools

Roughly shaping.

a. Double face hammer
b. Face hammer
c. Cavil
d. Pick

2. Dressing.

a. Axe or pean hammer
b. Tooth axe
c. Bush hammer
d. Crandall
e. Patent hammer

3. Architectural carving.

   a. Chisels { pitching / splitting
   b. Point
   c. Plug
   d. Feather

The double face hammer is designed for the purpose of shaping by percussive blows struck on the arrises and edges

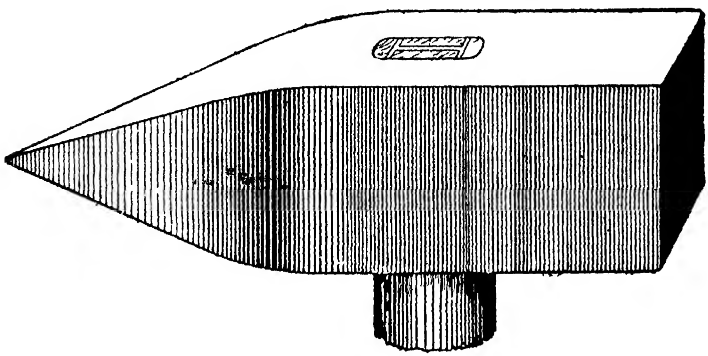


FIG. 5,531 —Cavel or pyramidal pointed hammer. *Used* for roughly shaping stone for transportation. *Weight*, 15 to 20 lbs

of each stone, being chiefly applicable to the rough rubble foundation walls, the stones of which being laid on their natural beds, are hammered to right angles, square corners and square and rectangular prisms, so as to bond in their lengths and widths. With it all corners are struck off, all rotten parts cut out with the chisel ends, and, if the stones be composed in layers, like slate or gneiss, it may be used for splitting horizontally or breaking vertically. Some stone masons prefer these hammers made with a square face at each end, but that shown is most popular

The following terms are those in general use by stone cutters

Definitions

Boasted.—Having face wrought with a chisel or narrow tool.

Broached.—Dressed with a "punch" after being droved.

Deadening.—The crushing or crumbling of a soft stone under the tools while being dressed.

Dressed Work.—That which is wrought on the face; also applied to stones having the joints wrought to a plane surface, but not "squared."

Drafted.—Having a narrow chisel draft cut around the face or margin

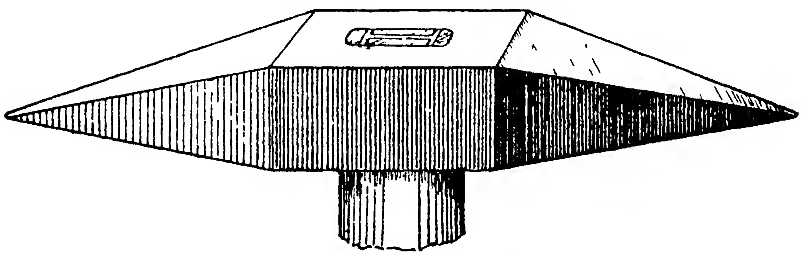


FIG. 5,532 —Pick. A double pointed tool whose length between points varies from 14 to 24 ins., the thickness at the eye being about 2 ins. *Used* for rough dressing mostly on sand stone and limestone

Droved, Stroked.—Wrought with a broad chisel or hammer in parallel flutings across the stone from end to end.

Herring Bone.—Dressed in angular flutings.

Nigged or Nidged.—Picked with a pointed hammer or cavil to the desired form.

Pitched.—Dressed to the neat lines or edges with a pitching chisel.

Pointed.—Dressed with a point or very narrow tool.

Polished.—Rubbed down to a reflecting surface.

Prison.—Having surfaces wrought into holes

Random Tooled or Droved.—Cut with a broad tool into irregular flutings.

Scabble.—To dress off the angular projections of stones for rubble masonry with a stone axe or hammer.

Square Droved.—Having the flutings perpendicular to the lower edge of the stone

Striped.—Wrought into parallel grooves with a point or punch

Vermiculated Worm Work.—Wrought into veins by cutting away portions of the face

Stone Cutting and Finishing.—In general, all stones used in building come under one of three classes:

1. Rough stones as they come from the quarry.
2. Stones roughly squared and dressed.

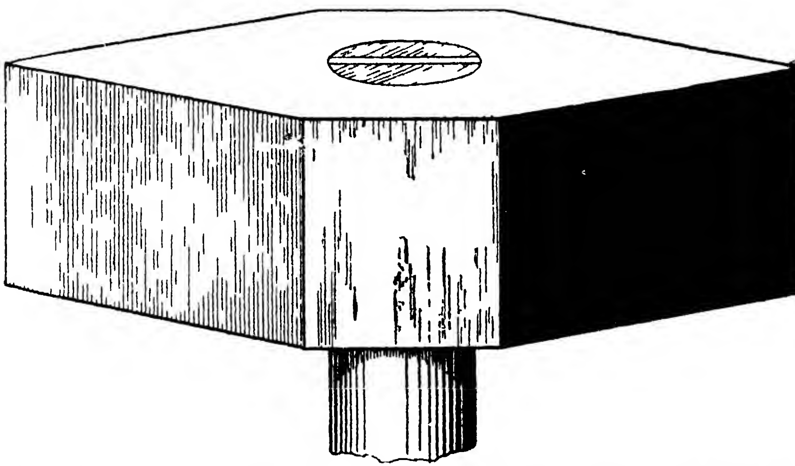


FIG 5 533 —Axe or pean hammer A double cutting edged tool *Used* for making drafts around the arris or edge of stones and in reducing faces and sometimes joints to a level Length about 10 ins and cutting edges 4 ins

3. Stones accurately squared and finely dressed, these are called "cut stones."

In practice the line of separation between them is not very distinctly marked, one class gradually merging into the next. A class of stones called "dimension" stones are those cut to special dimensions fixed in advance in the design of the

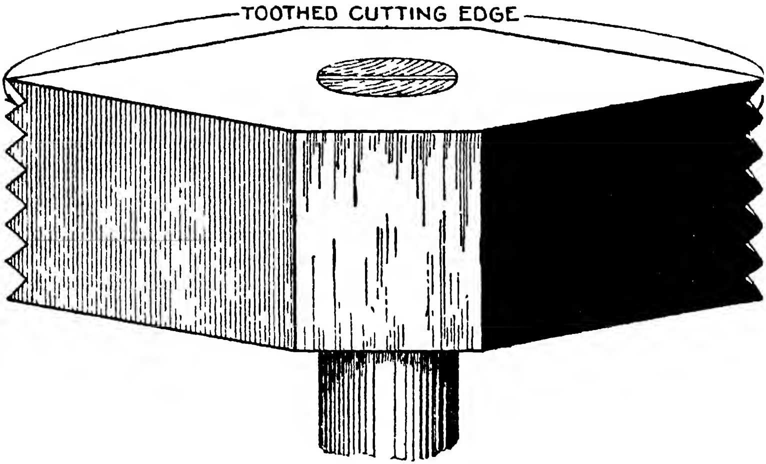


FIG. 5,534.—Tooth axe A double cutting tooth edged tool The size of the teeth vary with the service. *Used* for general cutting except in gneiss and granite.

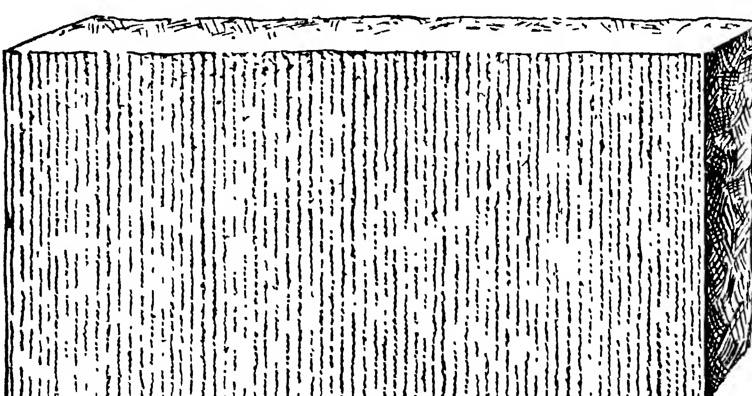


FIG. 5,535 —Axed finish.

structure for which they are intended. The axe or pean hammer shown in fig. 5,533 is used by granite cutters to obtain an "axed" surface like that shown in fig. 5,535.

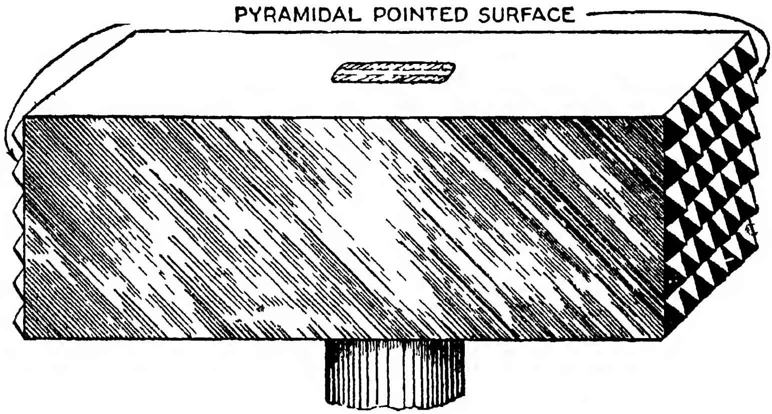


FIG. 5,536.—Bush hammer. A double faced hammer the surface of whose faces consist of a number of pyramidal points. The points vary in size according to service. The hammer varies in size, from 4 to 8 ins. and one end is sometimes made with a cutting edge like that of

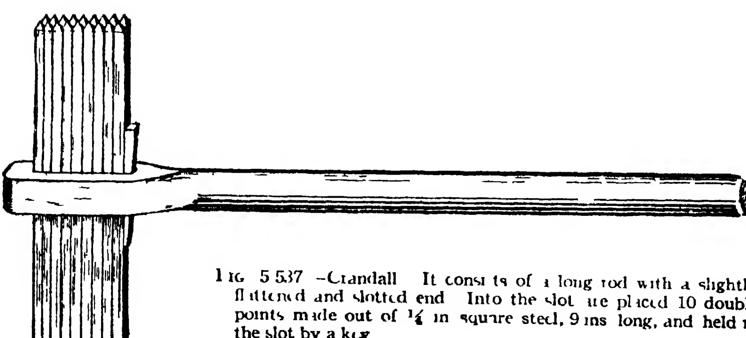


FIG. 5,537.—Crandall. It consists of a long rod with a slightly flattened and slotted end. Into the slot are placed 10 double points made out of ¼ in. square steel, 9 ins. long, and held in the slot by a key.

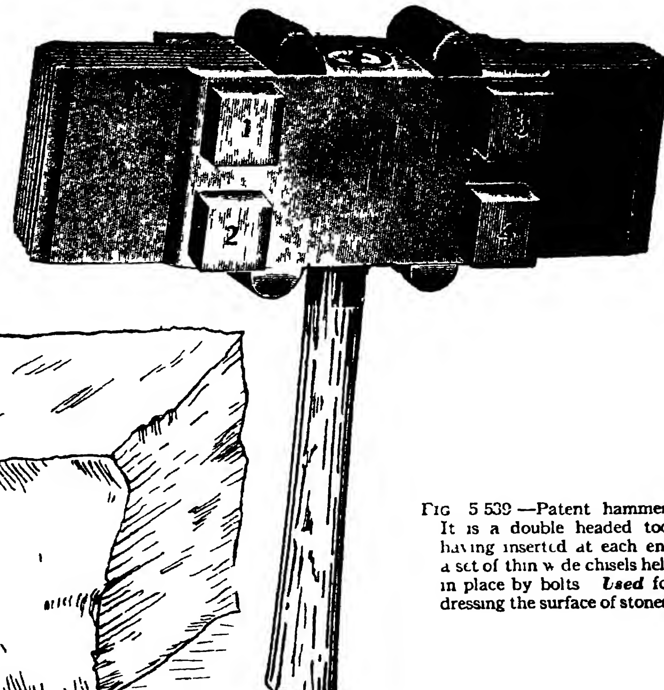


Fig 5 539 —Patent hammer It is a double headed tool having inserted at each end a set of thin wide chisels held in place by bolts *Used* for dressing the surface of stones

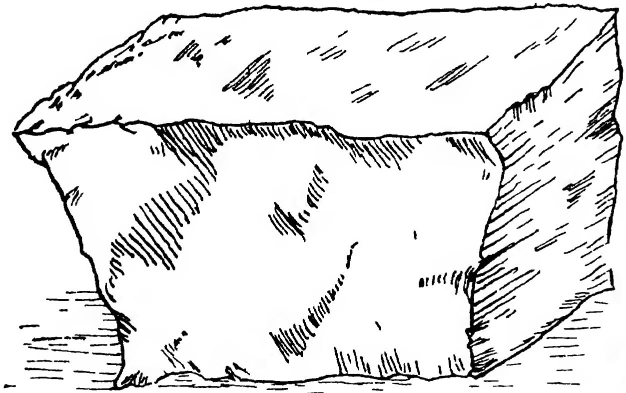


Fig 5 538 —Rock or quarry faced finish In this finish the faces of the stone are left untouched as they come from the quarry

The stone, being very hard, requires that the indentations be driven into the surface of the granite by sheer strength of the blows, which are given with the full force of the arms and body, and this hammer enables the cutters to do this, as it is tempered to an exceedingly hard capacity and can be ground to a knife edge.

The next cut finished face or surface is termed "rock" or "quarry" faced ashlar, which is formed by either dressing the arrises to a line out of wind and straight, or forming a parallel chisel draught one inch or more in width along the arrises

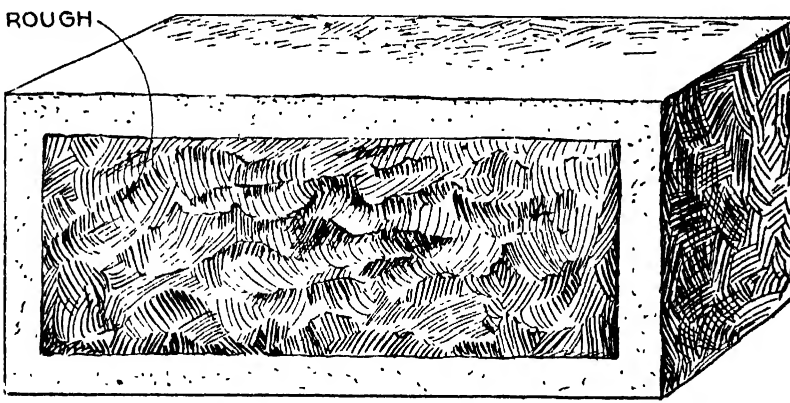


Fig 5,540.—Rough pointing. This finish is made with a pick or heavy point. The stone is thus worked until the rough projections vary from ½ to 1 in. Rough pointing precedes other operations in dressing limestone and granite.

and making the work rough either with the "face" hammer or point to make an appearance similar to that shown in fig. 5,538.

It must be remembered that the tools necessary to cut stone are many and will vary to suit the nature of the stone, as there is a strong contrast between the soft limestones of Ohio and the granites of Maine.

The next finish is called pointing of which there are two kinds:

1. Rough.
2. Smooth.

Rough pointing as shown in fig. 5,540 is a very deep cutting into the body of the stone and is generally used for large ashler stone; it is very decorative.

Smooth pointing, as shown in fig. 5,541, is usually used for basement work of private dwellings.

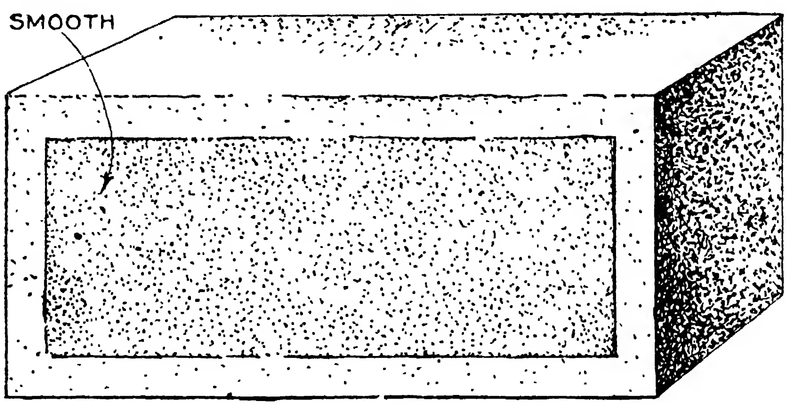


FIG. 5,541.– Smooth or fine pointing. This operation follows rough pointing where a finish smoother than rough pointing is desired.

It is a much finer tooling than rough pointing, and is done with a small point or tooth chisel. Much of the success of this work depends upon the delicacy of the blow to obtain regularity and uniformity in the pointings; so it is only by long practice that the mechanic becomes a skilled and successful stonemason.

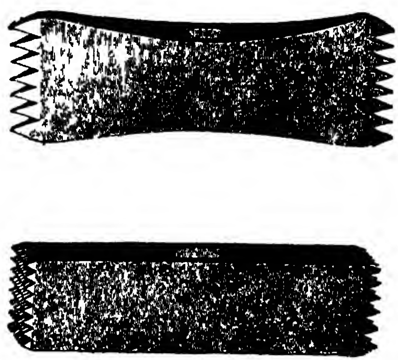
Smooth pointing is a final operation, that is, it is never made as a preparation for a last finish by another tool.

A finish called "tooth axing" is executed with the tooth axe,

which must not be confused with the bush hammer. The distinction between these two tools is shown in figs. 5,542 and 5 543.

The tooth axe is generally used on granite and the harder stones. The appearance of tooth axed finish is shown in fig. 5,544.

The bush hammer is used by the stone mason after he has roughed the surface down with the chisel The stone is bush



FIGS. 5,542 and 5,543 Distinction between tooth axe and bush hammer Note the row of sharp points in the tooth axe and the rectangular end of the bush hammer consisting of a rough surface composed of pyramidal points

hammered all over its surface, with the result that it becomes smooth, with a slightly ridged or corrugated face.

The appearance of a bush hammered surface is shown in fig 5,545 In making a bush hammered finish on limestone three operations are necessary 1, rough pointing, 2, tooth axing, and 3, bush hammering. Sandstone should not be bush hammered as it is liable to scale

The number of blades in a patent hammer varies from 6 to

12 and the number of cuts to the inch are specified as 6 cut,

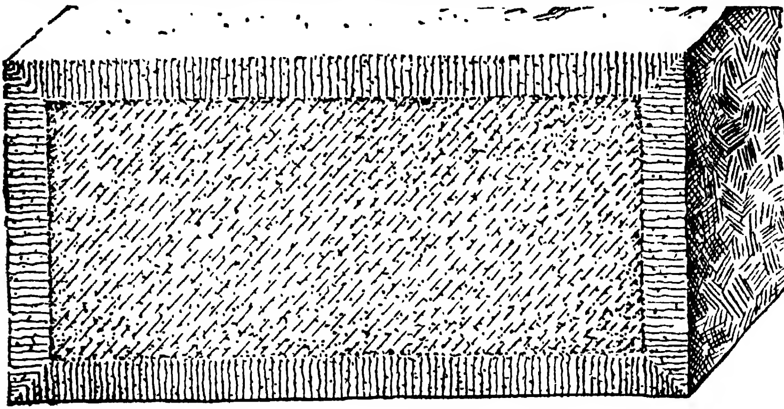


FIG. 5,544.—Tooth axed finish. *The tooth axe* leaves the surface of a stone in the same condition as smooth pointing. It is usually only a preparation for bush hammering and the work is in this case done without regard to effect so long as the surface of the stone is sufficiently levelled.

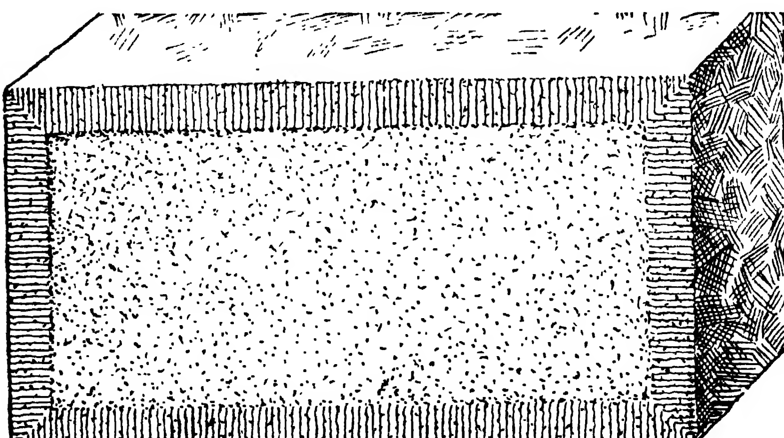


FIG. 5,545.—Bush hammered finish. *In making this finish* the pyramidal points of the bush hammer dig into the rough surfaces of the stone thus refining the roughness as shown.

8 cut, 10 cut, or 12 cut. The appearance of patent hammer finish is shown in fig. 5,546.

Crandall finish is a quick method. There are two kinds of crandall finish.

1. Straight.
2. Cross.

In the straight finish the marks are parallel to each other as in fig 5,547, and in the cross form they are rows of marks at right angles to the first

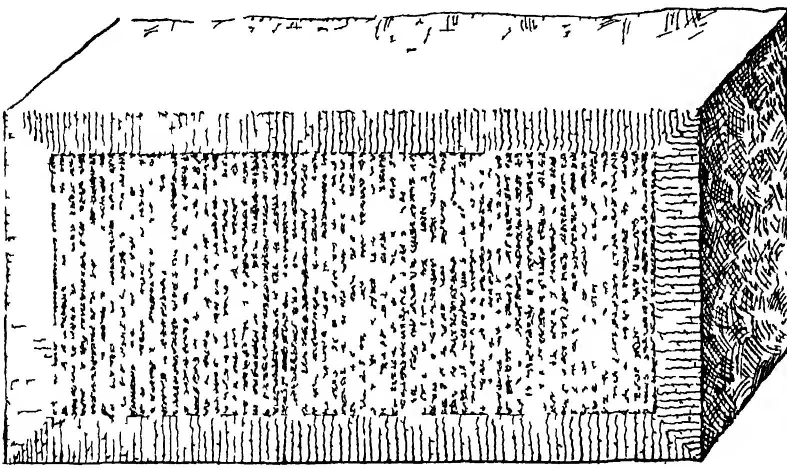


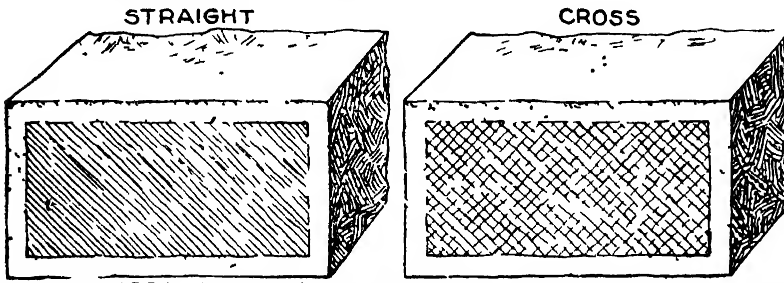
FIG. 5,546.—Patent hammer finish. *As can be seen* in the illustration patent hammers (and also axes) make straight marks instead of conical holes in the stone. These marks should be made parallel to each other over the entire surface. The patent hammer makes several marks at each blow, the number depending upon the number of blades in the set.

marks as shown in fig 5,548. In finishing stones, they are said to be drafted or have a draft line when a narrow chisel draft is cut around the face or margin.

In addition to the various finishes just described, there are numerous finishes that are made by machines. These machine finishes are possible with soft sandstones, limestones, and

others not too hard for machine working. Such stones may be turned, grooved, planed, mortised, fluted, etc., and the surface is easily given a smooth or ribbed finish.

Masonry Definitions.—The various definitions given in the following list should be noted.



FIGS 5,547 and 5,548 Straight and cross crandalled finish *In these finishes* the variations of level are about $\frac{1}{8}$ in

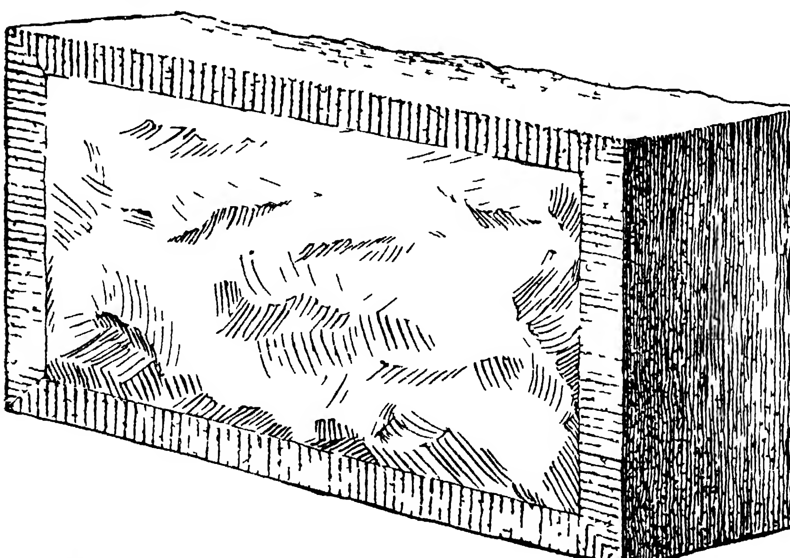


FIG 5,549 —Rough pointed stone

Masonry Definitions

Abutment.—A supporting wall carrying the end of a bridge or span and sustaining the pressure of the abutting earth.

Arris.—The external edge formed by two surfaces, whether plane or curved, meeting each other.

Ashlar.—A squared or cut block of stone, usually with rectangular dimension.

Backing.—That portion of a masonry wall built in the rear of the face. usually a cheaper class of masonry and bonded to the face.

Batter.—The slope or inclination of the face or back of a wall from a vertical plane.

Bearing Blocks. -Small blocks of stone built in the wall to support the ends of particular beams.

Bed. The top or bottom of a stone. Natural bed.—The surface of a stone parallel to its stratification. Course bed.—-Stone, brick, mortar or other material in position upon which other material is to be placed.

Bed-Joint.—A horizontal joint, or one perpendicular to the line of pressure.

Belt Stones or Courses. - Horizontal bands or zones of stone encircling a building or extending through a wall.

Binders. —When they extend only a part of the distance across the wall.

Blind Bond.—-Is used to tie the front course to the wall in pressed brick work where it is not desirable that any headers should be seen in the face work.

Block and Cross Bond. —When the face of the wall is put in cross bond and the backing in block bond.

Blocking Course.—A course of stone placed on the top of a cornice crowning the walls.

Bond.—In stone or brick masonry, the mechanical disposition of stone, brick or other blocks by overlapping to break joints.

Bonding Course.—Consisting of stretchers.

Breast Wall.—One built to prevent the falling of a vertical face cut into the natural soil; in distinction to a retaining wall, etc.

Brick Ashlar.—Walls with ashlar facing backed with bricks.

Broken Range.—Masonry construction in which the continuity of the courses are broken at frequent intervals.

Build.—A vertical joint.

Build or Rise.—That dimension of the stone which is perpendicular to the quarry bed.

Buttress.—A vertical projecting piece of stone or brick masonry built in front of a wall to strengthen it.

Centering or Centers.—A temporary support of an arch during construction.

Chain Bond.—Is the building into the masonry of an iron bar, chain or heavy timber.

Clamp.—An instrument for lifting stone, so designed that its grip is increased as the load is applied.

Closers.—Pieces of brick or stone inserted in alternate courses of brick and broken ashlar masonry to obtain a bond.

Corbell.—A horizontal projecting piece or course, of masonry which assists in supporting one resting upon it which projects still further.

Course.—Each separate layer in stone, brick or other masonry.

Course Bed.—Stone, brick or other building material in position, upon which other material is to be laid.

Counterfort.—Vertical projections of stone or brick masonry built at intervals along the back of a wall to strengthen it, and generally of very little use.

Coping.—A top course of stone or of other building blocks, or of concrete to shelter the masonry from the weather.

Cramps.—Bars of iron having their ends turned at right angles to the body of the bar in order to enter holes in the faces of adjacent stones to hold them in place.

Cross Bond.—In which the joints of the second stretcher course come in the middle of the first; a course composed of headers and stretchers intervening.

Cutwater or Starling.—The projecting ends of a bridge pier, etc., usually so shaped as to allow water, ice, etc., to strike them with but little injury.

Dimension Stone.—Blocks of stone cut, or quarried to be cut, to specified dimensions.

Dowels.—Straight metal bars used to connect two sections of masonry. Also, a two-piece instrument for lifting stones.

Draft.—A margin on the surface of a stone cut approximately to the width of the chisel.

Dry Stone Walls.—May be of any of the classes of masonry previously described, with the single exception that the mortar is omitted. They should be built according to the principles laid down for the class to which they belong.

English Bond.—(Brick masonry) consists of alternate courses of headers and stretchers.

Extrados.—The upper curve of a right section of an arch, perpendicular to the axis

Expansion Joint.—A vertical joint or space to allow for temperature changes.

Face.—The exposed surface of a stone, in elevation.

Facing.—The projecting courses at the base of a wall for the purpose of distributing the weight over an increased area, and thereby diminishing the liability to vertical settlement from compression of the ground.

Flush.—Having the surface even with the adjoining surface.

Footing.—A bottom course.

Grout.—A mortar of liquid consistency.

Header.—A stone having its greatest dimension at right angles to the face of the wall in which it rests.

Heart Bonds.—When two headers meet in the middle of the wall and the joint between them is covered by another header.

Intrados.—The lower curve of a right section of an arch, perpendicular to the axis.

Joint.—The narrow space between adjacent stones, bricks or other building blocks usually filled with mortar.

Lagging.—Strips used to carry and distribute the weight of an arch to ribs or centering during construction. Also used to designate the strips temporarily supporting soft material, as outside the timbering of a tunnel

Lewis.—A four piece instrument for lifting stone.

Lock.—Any special device or method of construction used to secure a bond in masonry.

Natural Bed.—The surface of a stone parallel to the stratification.

Parapet.—A wall or barrier on the edge of an elevated structure for the purpose of protection or ornament.

Paving.—Regularly placed stones or bricks forming a floor.

Perpend Bond.—Signifies that a header extends through the whole thickness of the wall.

Pitch.—To square a stone.

Pitch Stone.—Stone having the arris clearly defined by a line beyond which the rock is cut away by the pitching chisel, so as to make approximately true edges.

Plinth Course.—A lower, projecting, squarefaced course; also called the water table.

Pointing.—Filling the joints or defects in the face of a masonry structure.

Range Work.—In this construction a course of any thickness, once started, is continued across the entire face; but all courses need not be of the same thickness.

Ring Stones.—The end voussoirs of an arch.

Riprap.—Rough stones of various sizes placed irregularly and compactly to prevent scour by water.

Rowlock Course.—Bricks set on edge.

Rubble.—Field stone or rough stone as it comes from the quarry.

Rubbed.—A fine finish made by rubbing with grit or sandstone.

Set.—A change from a plastic to a hard state.

Skewbacks.—Their upper surfaces are cut at such an angle that the surfaces are approximately perpendicular to the direction of thrust of an arch.

Slope Wall.—A wall to protect the slope of an embankment or cut.

Soffit.—The under side of a projection.

Spandrel Wall.—The wall at the end of an arch above the springing line and extrados of an arch, and below the coping or string course.

Spall.—A chip or small piece of stone broken from a large block.

Springer.—The first arch stone above a skewback.

Springing Course.—The course from which an arch springs.

Springing Line.— The upper and inner edge of the line of skewbacks on an abutment.

Stretcher.—A stone or other block with its longest dimension parallel to the face of the wall in which it rests.

String Course.—A projecting course.

Through Bonds.—When they extend clear across from face to back.

Voussoirs.—The individual stones forming an arch. They are in the form of truncated wedges.

Wing Wall.—An extension of an abutment to sustain the adjacent earth.

Classification of Masonry.—Stone masonry may be classed in various ways, as for instance according to the kind of stone used, surface finish, bonding, etc., but perhaps the best classification is with respect to the degree with which the shape of the stones are worked to approach a rectangular shape. Accordingly with respect to the general shape of the stones, the masonry made from them may be classed as

1. Unsquared or rubble.

   a. Uncoursed
   b. Random coursed
   c. Coursed

2. Roughly squared.

   a. Quarry or rock faced
   b. Pitched face
   c. Drafted

3. Squared.

   a. Range
   b. Broken range
   c. Random

4. Cut.

a Ashlar { range / broken range / random }

b Dimension

Unsquared or Rubble Masonry.—Unsquared masonry generally known as rubble masonry is composed of unsquared

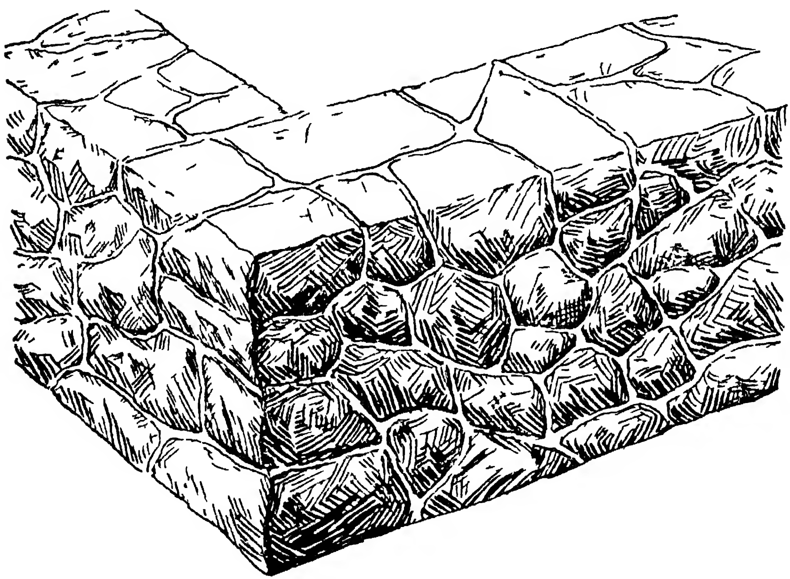


FIG. 5,550—Uncoursed or cobweb rubble

stones as they come from the quarry, the irregularities being made up by filling with mortar as the stones are set. The stones may be either quarried, or field stones. The quarried variety is preferable because they approach more nearly a rectangular shape and are better for stone work because their

faces are sharper and form a better hold for the cement than the weather worn and smoother surfaces of field stone. However, field stones, beach or cobble stone are much used in building rural and seashore houses.

The three kinds of rubble masonry, known as uncoursed, random coursed, and coursed are shown in figs. 5,550 to 5,552.

Many foundations and underpinnings have been built of

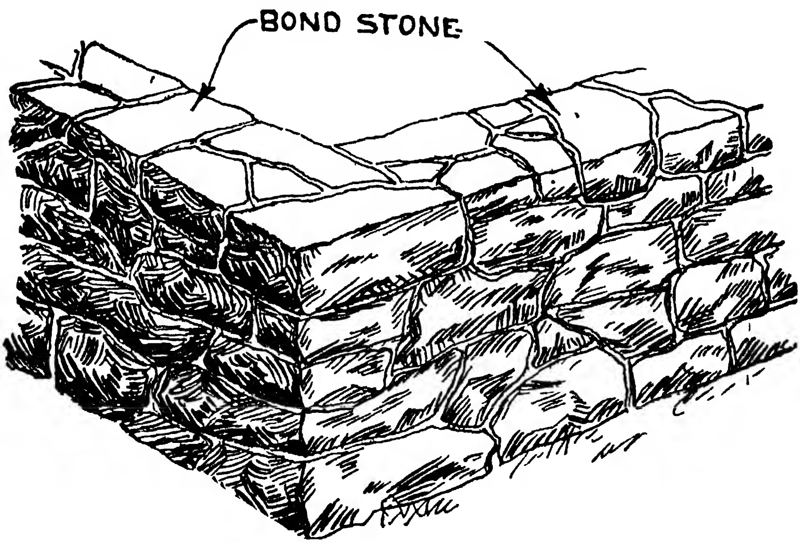


FIG 5,551 —Random coursed rubble

"cobweb" rubble, which is especially adapted for use in building suburban and country residences; if the joints be skillfully made and mortar show about the same in all places, an attractive and serviceable wall will result.

Hard limestone or sandstone make excellent foundations excepting in very wet locations.

As these stones are stratified and are formed in the ledge of different

thicknesses, each of which is uniform throughout the entire ledge, they are easily quarried and may be readily trimmed so that each stone will extend through the wall. As all joints may be either lever or plumb, the stones may be laid more easily than any other kind. A stone of this sort should be placed upon its natural bed; that is, as it laid in the ledge. This can be found by determining the layers which form the stone.

If these be placed horizontally they will give no trouble If placed vertically and rain penetrates the stone and is followed by extremely cold

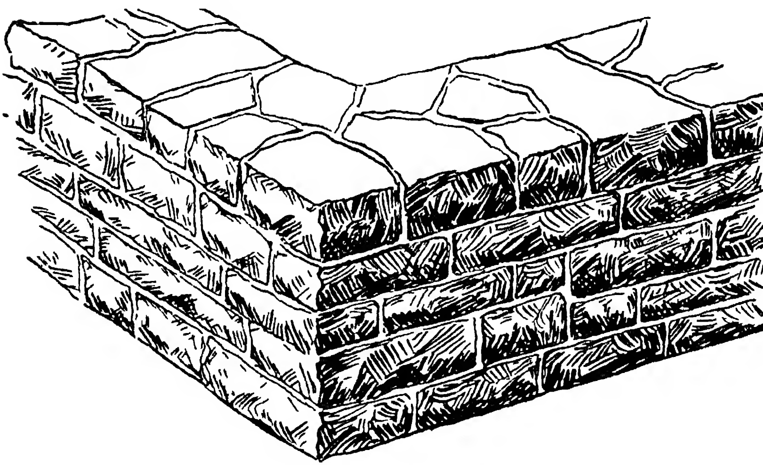


FIG 5,552 —Coursed rubble Note the through bond stones.

weather the face layers may peel off This is not true of either granite or dendrite, which are much harder to cut and shape but are impervious to water A good building stone should respond to a sharp blow with a hammer by a ringing sound, and its fracture should be clean and sharp. If soaked in water over night, its weight should not increase more than four per cent Soft sandstone will absorb more water, but the ease with which it may be worked makes it a favorite building stone wherever it can be obtained locally

A rubble wall should be built double and not less than eighteen inches thick unless sandstone is used.

Each stone should extend through the wall, in which case twelve inches is thick enough for an ordinary dwelling. The bottom or footing course should be laid of the largest, straightest stones, as the stability of the wall depends largely upon the bearing of the stones on the ground

Sometimes a cobble stone veneer facing is used on a rubble backing as shown in fig. 5,554.

The stone mason should hammer dress inequalities which prevent the stone facing up with the rest of the wall, or that will interfere with bedding

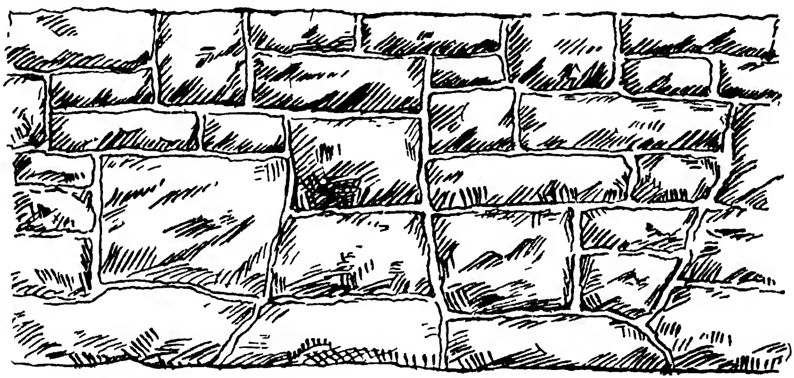


FIG. 5,553 —A poorly built random coursed rubble wall

or fitting the next course. Often, instead of doing this "spalls" or pieces broken off in trimming are slipped under stones which do not bed firmly, it being easier than the imposed labor handling and trimming and correct setting, thus it becomes a more popular method among stone masons. Though contrary to the best practice, if these spalls be judiciously used and set in mortar so as to actually support and hold the stone so that it cannot move or be displaced, it simplifies and cheapens the making of a rubble wall and proves very satisfactory for an ordinary building, but in heavy construction they should only be used for filling interior cavities when leveling for courses.

Bond stones as shown in fig. 5,552 should cover the thickness of the wall at frequent intervals of not over 4 feet; their ends should be hammer dressed to conform to the wall on either side.

The corners must be of large stones that will bond the two walls together in the best manner to resist strain. Additional strength may be given to the wall by the addition of galvanized iron or wire bonds, especially if small stones are used.

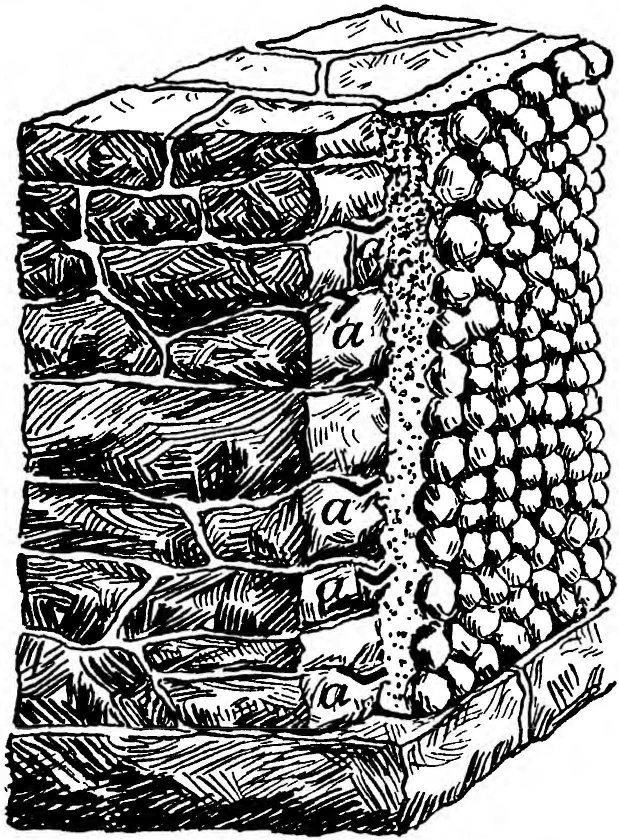


FIG. 5,554.—Cobble stone veneer over random coursed rubble. A wire bond similar to that indicated at A, is set in the cement of the wall and the veneer to hold the latter firmly in place.

The skilled mason will endeavor to use up all sizes and shapes of stone to the best advantage and the least cutting

by sorting and placing at the same time preserving the strength and quality of the wall, and will bring each course to as near a level as possible

He will brush or wash all loose dirt from stone before laying them into mortar as it prevents contact of mortar to stone. He will not depend upon the thin edge of a stone to support any weight. He will not lay a long stone without bedding it in mortar uniformly, and if too long, will break it and lay it as two stones, indeed, for the best class of work he will spread the mortar, force the stone to its bed without its touching the stone underneath, and maintain a perfect alignment with the face of the wall. He will avoid the presence of continuous joints as shown in the poorly built wall fig. 5,553.

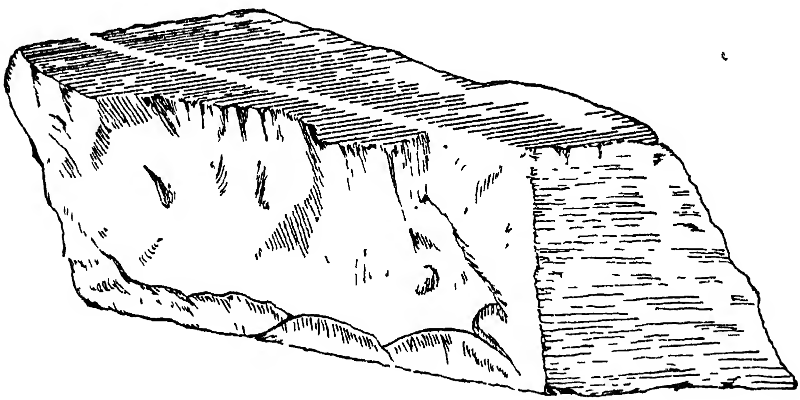


FIG 5 553 — Pitch faced roughly squared stone

Roughly Squared Masonry.—This kind of masonry sometimes erroneously called "squared masonry," covers all stones that are roughly squared and dressed on beds and joints. The distinction between this class and the next class or squared masonry lies in the degree of closeness of the joints which is demanded. In this class the joints are between ½ and 1 in. in thickness and consist of stones less accurately dressed than in the case of ashlar. Various divisions of roughly squared

masonry are made depending on the finish given to the face of the stones, such as quarry face, pitched face, drafted stones, etc.

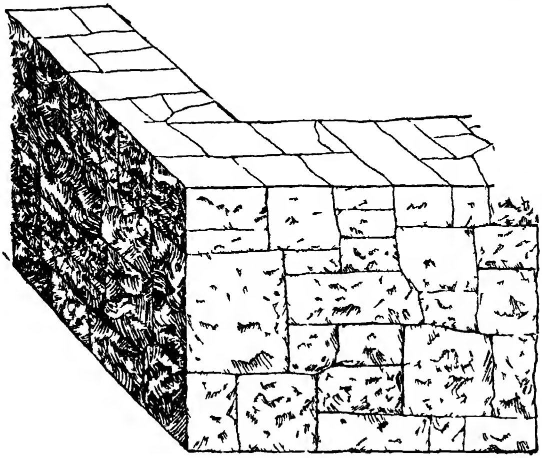


Fig 5 556 —Quarry faced roughly squared masonry

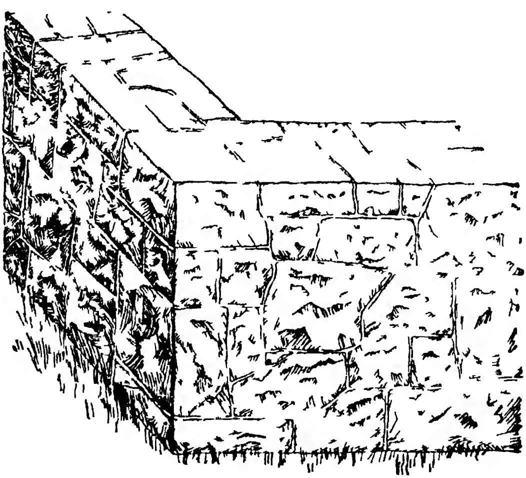


Fig 5 557 —Pitch faced roughly squared masonry

Squared Masonry.—The difference between this kind of masonry generally called "ashlar" or cut stone masonry, is the precision in cutting to a true surface. Thus the roughly squared masonry just described requires ½ to 1 in. thickness for joints to allow for the unevenness of surface, the squared or ashlar masonry due to the surface being cut smoothly, requires only ½ to ⅜ in. thickness of joint. In order that

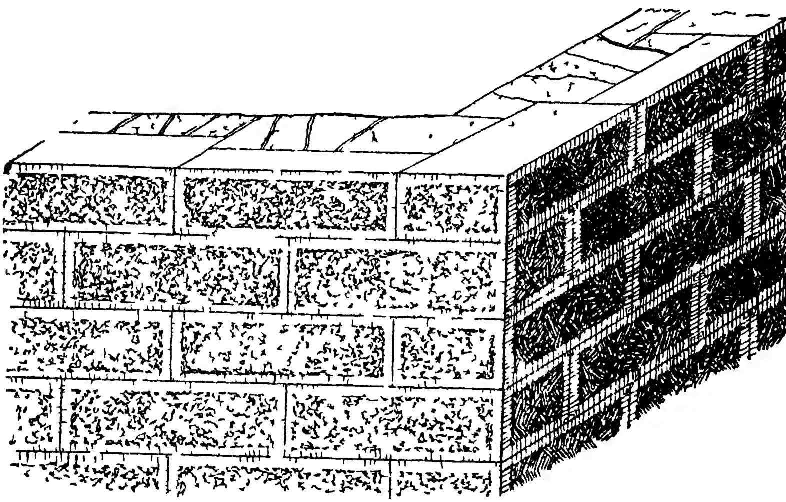


FIG. 5,558.—Coursed ashlar. The stones are uniform in size and the bed joints are continuous.

the stones may not be liable to be broken across, no stone of a soft material, such as the weaker kinds of granular limestone and sandstone, should have a length greater than 3 times its depth or rise.

In harder materials the length may be 4 to 5 times the depth. The breadth in soft materials may range from 1½ to double the depth, in hard materials, 3 times the depth.

When the outside facing of a wall is of squared or cut stone

it is called ashlar regardless of the manner in which the stone is finished.

Ashlar is usually laid either in regular courses with continuous horizontal joints, as shown in fig. 5,558, or in broken courses without regard to continuity of joints, as shown in fig. 5,559.

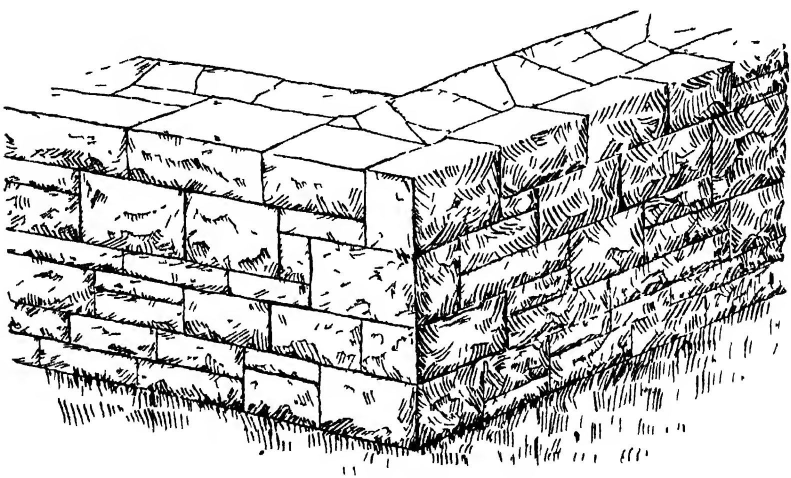


FIG 5,559 —Broken ashlar The stones vary in size and is desirable where stones of uniform size cannot be cheaply obtained

Broken ashlar is more expensive than coursed ashlar because it takes more time to fit and lay the different sizes of stone It should have no horizontal joints more than 4 ft long and several sizes of stone should be used.

Broken ashlar is often arranged random fashion as shown in fig. 5,561, the courses being 18 to 24 inches high

If ashlar in regular courses and sizes is to be used, drawings showing each different-sized stone, the heights of the courses and other necessary

details The plans usually show every stone, unless broken ashlar be used, in which case it is only necessary to show the quoins and jambs on the drawings, together with enough of the ashlar to indicate the character of the work desired It is almost impossible to carefully follow a drawing showing all the stones laid as broken ashlar

Bonding.– In stone work as well as brick work it is important to secure a good bond. In bonding the following rules should be followed:

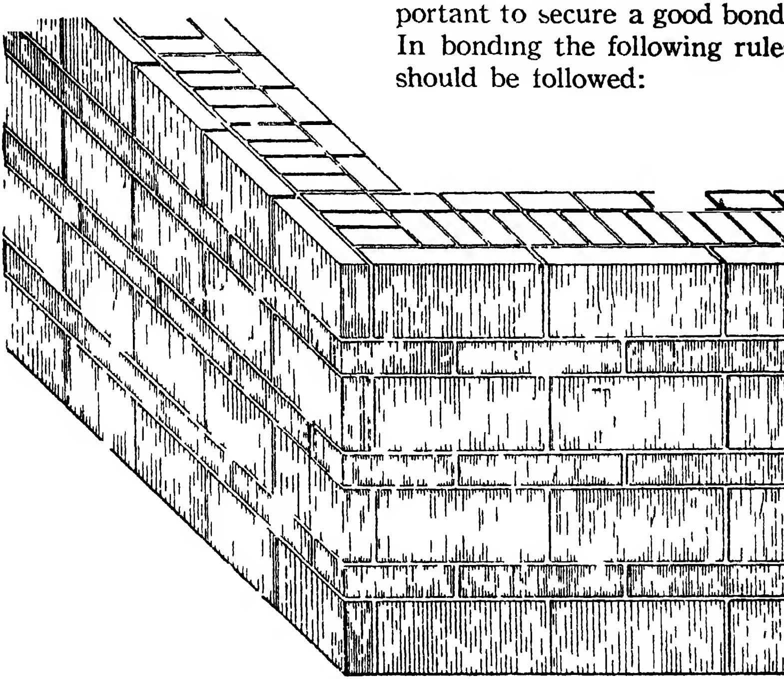


FIG 5,560 —Smooth finish cut stone masonry alternate narrow and thick courses and brick backing

1. Headers should extend not less than ⅔ the thickness of the wall

2. For foundations there should be a header for every five sq ft of surface of wall.

3. The vertical joints of each course should break with the joints of the course below.

4. The lap should be not less than 4 ins.

5. The mean thickness of a rubble wall should be not less than ½ of the height.

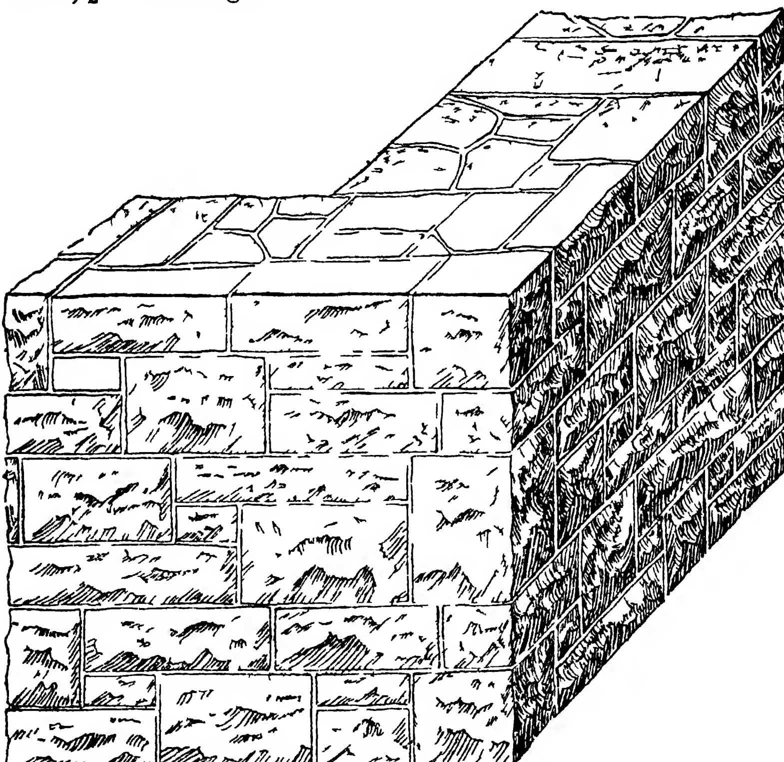


FIG 5 561 —Random coursed broken ashlar A desirable masonry for piers or other structures where extra strength due to good bonding is essential

6. The largest stone should be used for the lower course.

7. Stratified stone should be laid on its natural bed.

Various methods of bonding are shown in the accompanying illustrations figs. 5,565 to 5,572.

Fig. 5,573 shows how one stone may be exactly centered over another and prevented slipping by exact center drilling and a perfect fitting dowel

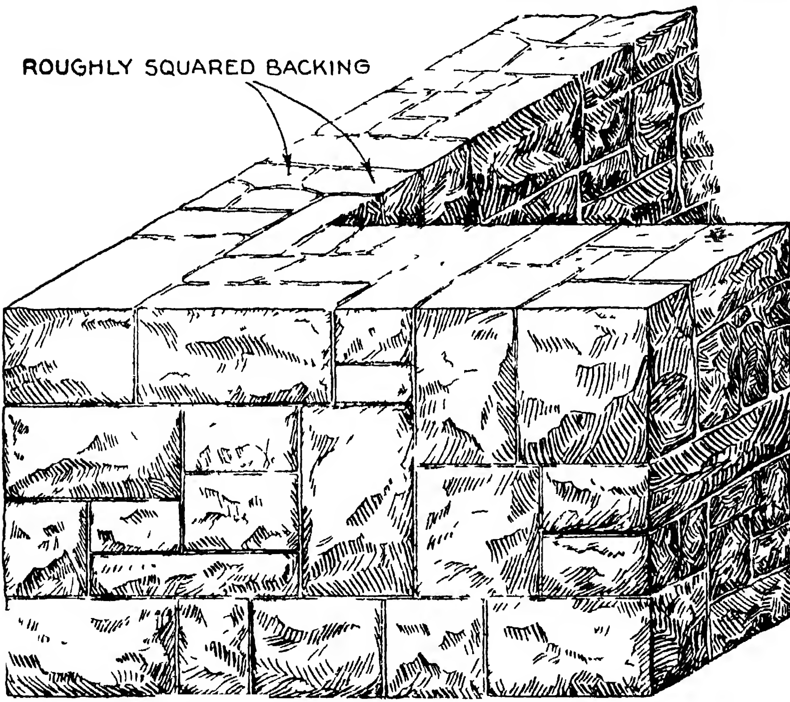


Fig. 5,562 —Uncoursed ashlar with roughly squared backing

as at C. It is illustrated by rough chisel or broken face stones with their edges or corners bush hammered or crandalled.

Stone Setting. –In the specialization of labor it has come about that the stone mason, instead of doing all the work, simply cuts and manipulates the stone to given sizes in the

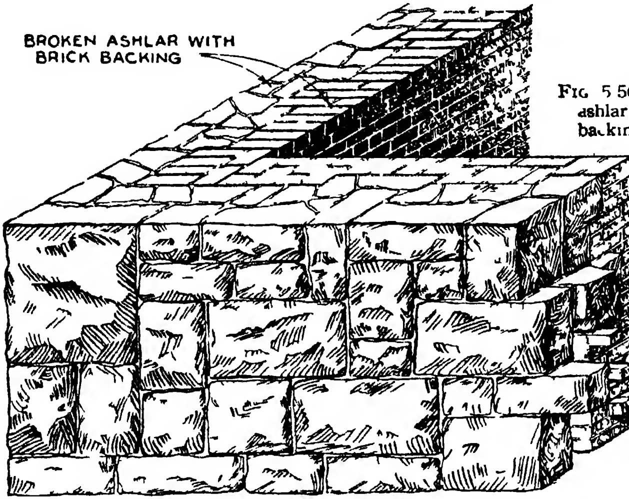


FIG. 5,563 —Broken ashlar with brick backing

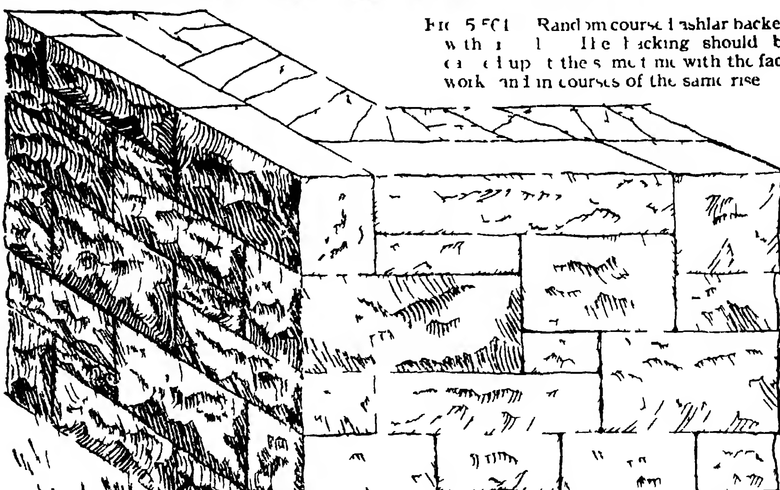


FIG. 5,564 —Random coursed ashlar backed with rubble. The backing should be carried up at the same time with the face work and in courses of the same rise

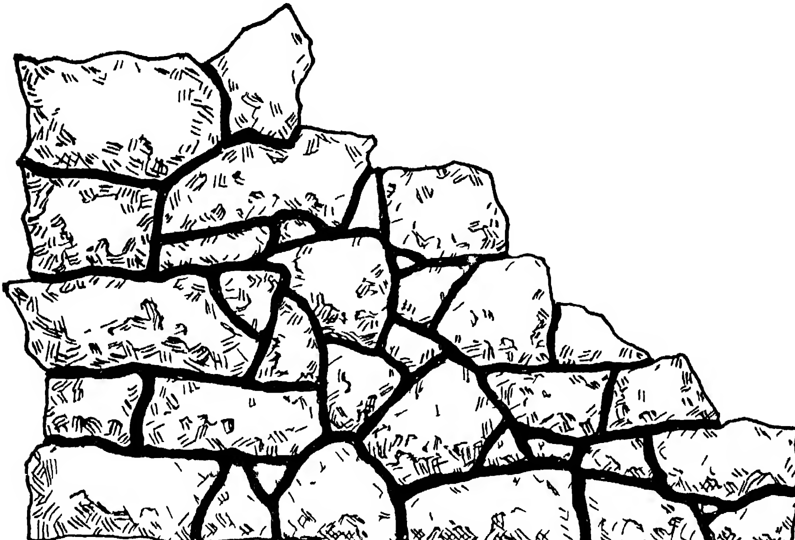


FIG 5 565 —Rustic rubble random bond.

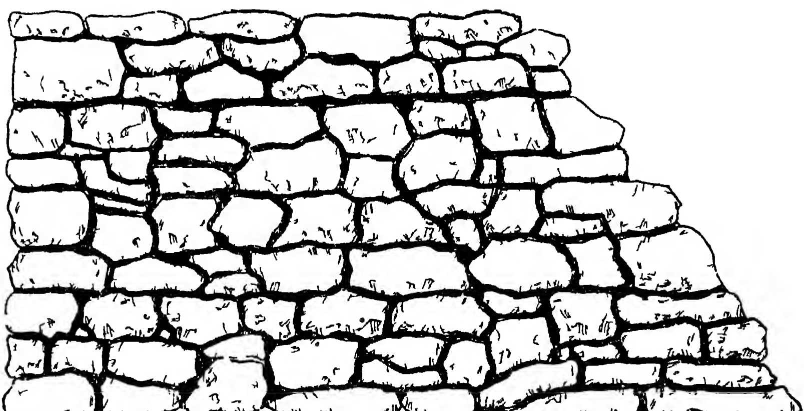


FIG 5 566 — Coursed rubble random bond

stone yard, while the stone setter places them, when wrought and delivered at the works, in the walls of the building.

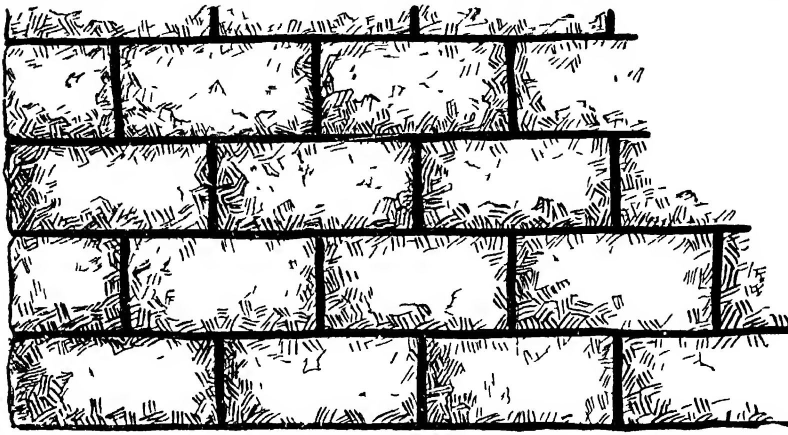


FIG. 5,567 —Coursed bond.

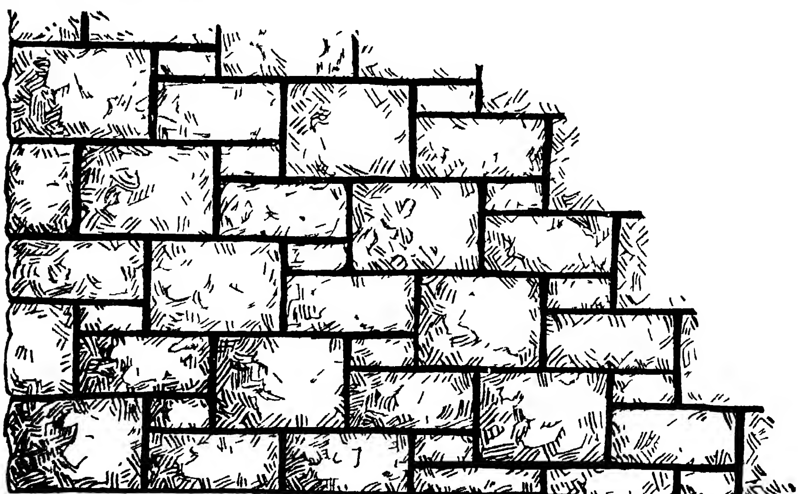


FIG. 5,568 —Broken bond, two against one

Naturally a stone setter must be a practical and experienced stone mason, though this class of work involves other knowledge in addition to the art of cutting the stones.

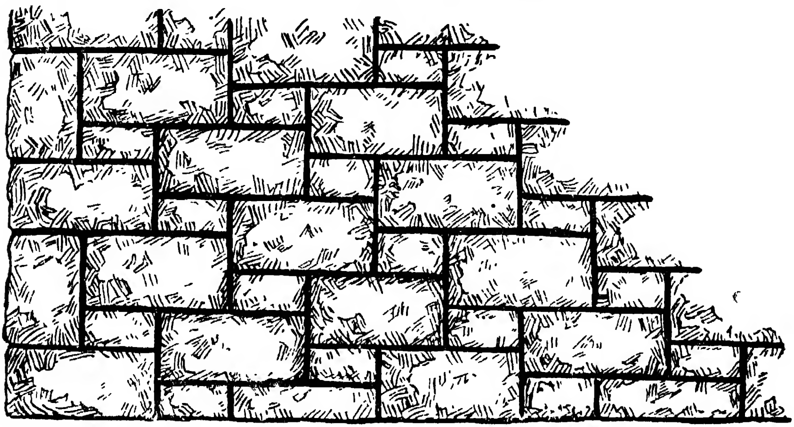


FIG. 5,569.—Broken bond; two against two.

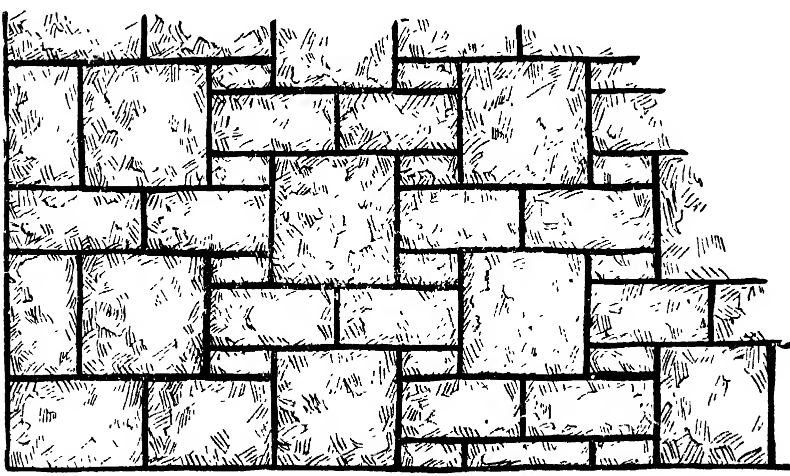


FIG 5,570 —Broken bond; three against one.

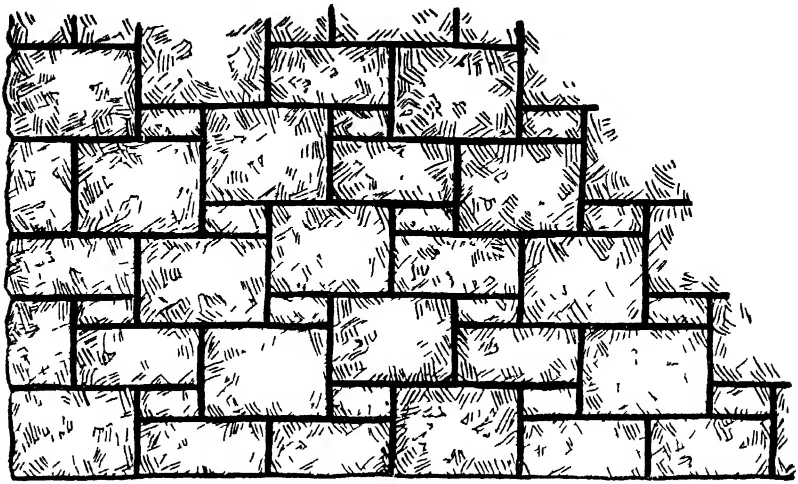


Fig. 5,571 —Broken bond combination of two against one and two against two

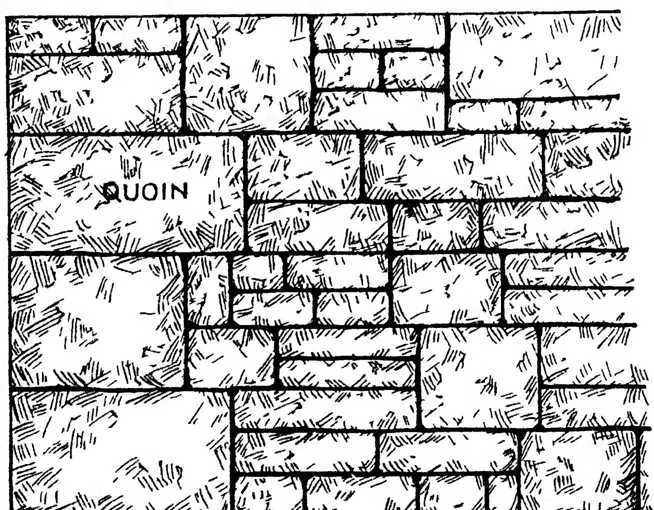


Fig. 5,572 —Broken bond irregular or snecked rubble

He must also be conversant with blue prints to interpret the layout and placing of dimension stone work. Because of the heavy weight of the stones, the stone setter will require special tools and appliances to lift them from the ground to

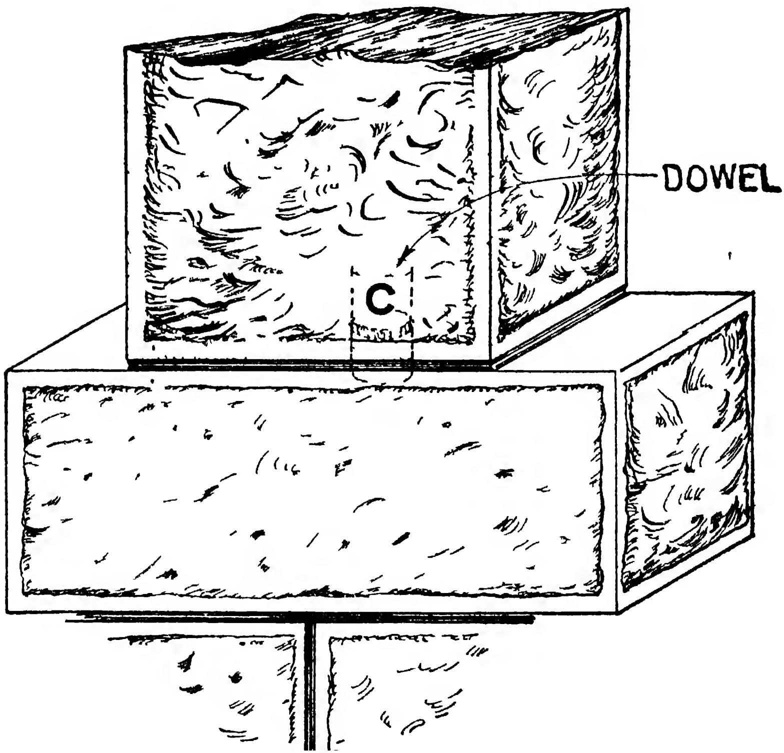


FIG 5 573 —Round dowel between stones to secure them in position when setting

their beds on the courses in the walls. The first and obviously the most essential appliance is the setter's lifting derrick, as shown in fig. 5.574.

The following table gives the capacity of these derricks as usually made, though for very heavy stone blocks special extra strong derricks are made:

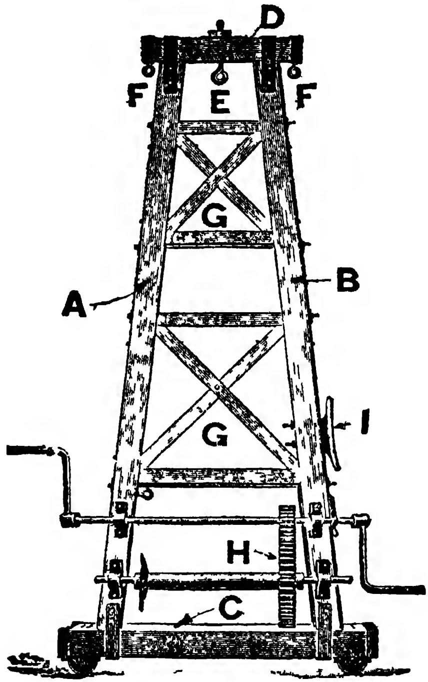


FIG 5 571 —Stone setter's derrick *It consists of* two main sloping square or round timber legs A and B tenoned and mortised into a bottom tie piece or bearer C and kept together at the top by a cross piece D similarly framed which serves to support the lifting tackle by means of an eye bolt at its center E and having eye bolts at the ends to which the guy or stay ropes are attached FF as seen in the sketch The whole framing is kept true and rigid by diagonal pieces of wood or iron with cross spreaders to keep it from warping or succumbing under the weight when lifting About three feet up from the bottom piece which by the way is equipped with cast iron rollers a crab or windlass H with power spurred wheels is fitted the larger gear having a drum on which the rope from the hoisting tackle is wound and this is fitted with a pawl or ratchet to prevent the weight from rapidly pulling on the rope and injuring the derrick man who winds also for setting the tackle at any fixed height when the setter so desires the guys being operated through single blocks placed at FF, and belayed or half hitched to the belaying pin I All this is done by the derrick man standing at the right the man at the left simply acting as power and turning

Stone Mason's Derricks

(Table of standard sizes)

Height feet	Width of top, ins	Length of drum	Width of foot	Size of timber in legs, ins.	Size of timber in ft. ins. square
22	18	3 ft., 9 ins	6 ft.,6 ins	3 ×6	6
25	20	4 "	6 " 6 "	3½×6	6
28	24	4 " 6 "	7 " 4 "	4 ×6	6
30	30	5 "	8 "	4 ×7	7
35	42	5 "	9 "	4 ×7	7
40	42	5 " 6 "	10 " 6 "	4 ×8	8

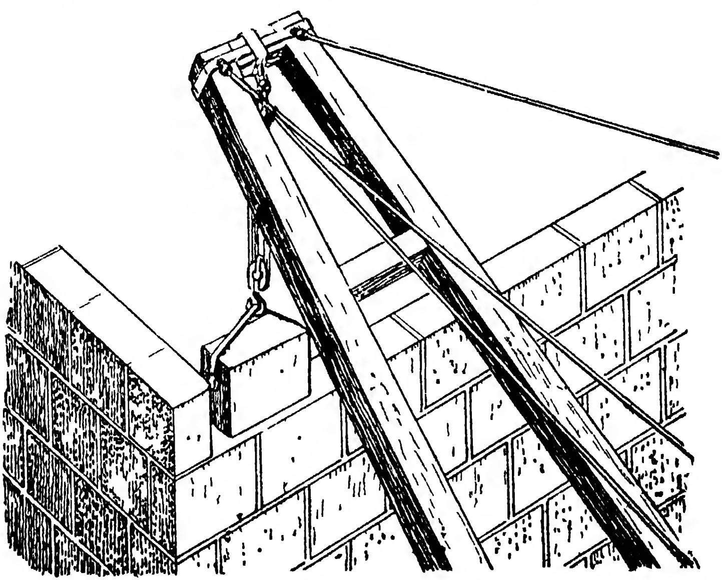
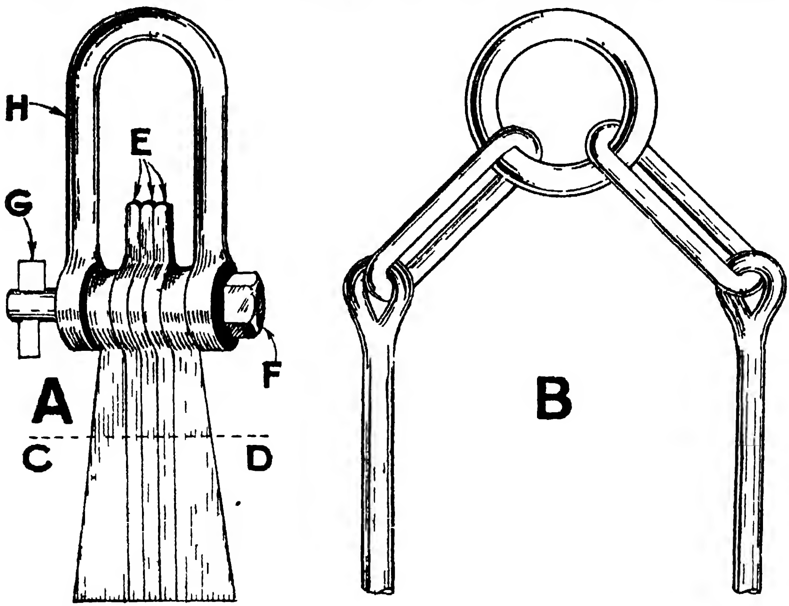


FIG 5,575 —Stone setter s derrick in position alongside of measuring wall showing method of placing a stone.

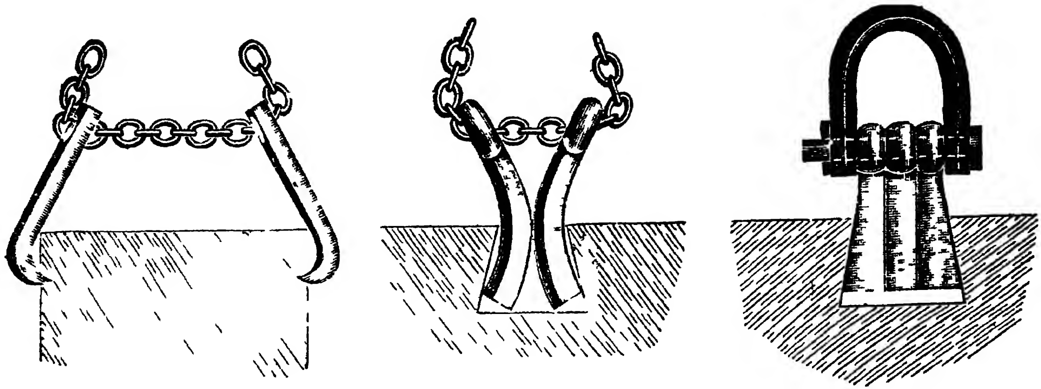
For greater heights a stout spruce pole, termed a gin pole, is lashed to the center of the derrick.

The rope used is generally 1 in. or $1\frac{1}{4}$ in. of the best Manila, and properly rendered flexible and pliable before using, also tested to prove its efficiency and safety. When the setting begins, the base of the derrick is placed on a strong plank, as shown in fig. 5,575 and rolled along the front from left to right, as the ashlar follows course by course. It leans forward from ten to twenty-five degrees of the perpendicular, and when the stone is raised to



Figs. 5,576 and 5,577.—Two forms of lewises used on stone setter's derrick. The lewises (fig. 5,576) are taken apart by backing out the pin key G, and withdrawing the pin F which will release the right and left dovetailed sides with the three tapering wedges E. The shackle, H, is forged with eye bolts and is necessary for attaching the hook of the fall from the derrick when raising the stones.

the desired level, the top is moved by regulating the guy ropes and pitched toward the front wall until the stone is directly over its bed, when it is gradually lowered to its bed. Then, by an oscillating movement the stone is set level, flush on the face, and plumb. Should the stone not fit in any way, it must be lifted from its position and properly fitted.



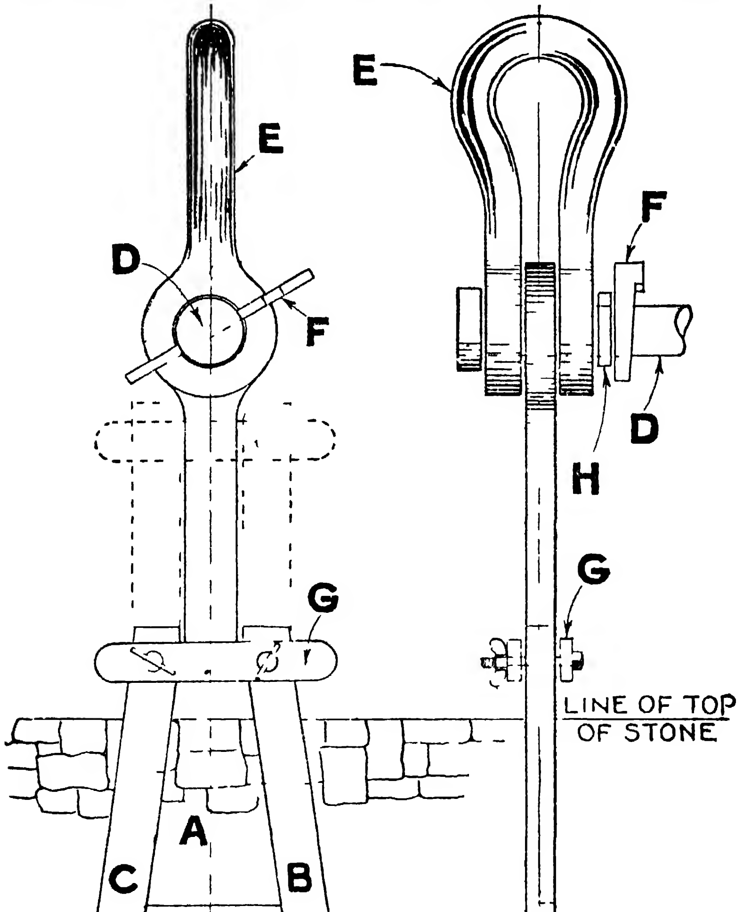
FIGS 5,578 to 5,580 Various lewises Fig 5,578 iron claw lewis which fits nut holes prepared in the sides of the stone, fig 5,579 rod lewis or chain lewis in which the pull of the lifting chain tends to pull the two bent wedges close together at the top causing them to grip the stone tightly fig 5,580 dovetailed lewis the dovetail pivoted pieces of A and C, are first put into a similar dovetail recess cut in the stone immediately above its center of gravity The center or locking piece B, is next inserted the shackle brought to its place and the whole joined together as shown

As the faces of the ashlar or carved stones are liable to be marred in setting, the stone setter employs a tool or appliance of very ancient usage, termed a "lewis," or "lewises"

This device is made in two forms as shown in figs 5,576 and 5,577, the latter form is more in use for ordinary setting on three to seven story buildings, where only light stones are required, and the former (fig 5,576), where the stones are heavy, long or narrow, or of such shape as not to balance properly, necessitating the placing of the pins far apart

Much care is required in fitting the lewis into the top beds of the stones, because it must be tight and

not likely to pull out when lifted The center of the bed is found by drawing diagonal lines across the stone from corner to corner, giving an



FIGS 5 581 and 5 582 Wedge type of levers *It consists of* two parts made up as follows The main shank or stem A in the center and two jaws B and C, pivoted to the link G A shackle E, is pivoted to the shank A by the pin D secured by key F. *In operation* the chains of the hoisting pulley force the jaws against the sides of the angularly bored holes in the stone thus securely clutching the latter

intersecting point which will be the point where the mortise for the lewis is to be made. This mortise must be no wider at the top than the width of the lewis at CD, and must be dovetailed on the ends to suit the slope of the two outside keys, and sunk from three to six inches in the stone to prevent its breaking out; and the power, which can only be determined by the hard or soft qualities of the stone, must be left to the discretion of the setter.

In order to place the lewis in the mortise in the top bed, the two sloping outside pieces are set in on each side and the tapering wedges driven down

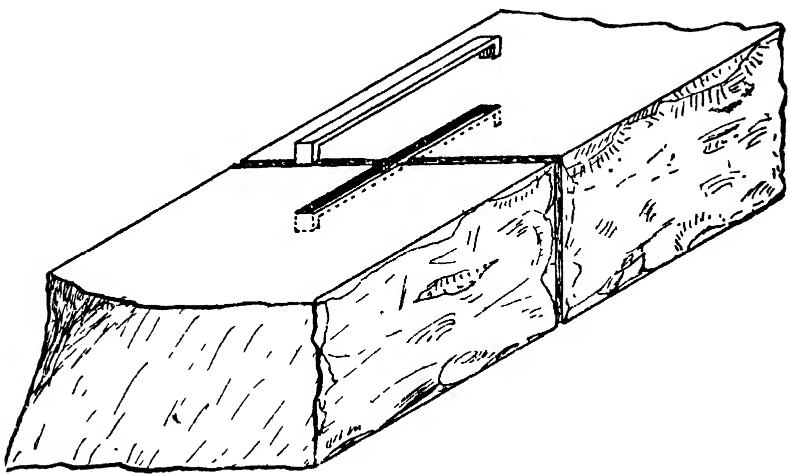


FIG. 5,583.—Clamp or lug joint. All such ties should be either galvanized or dipped in hot tar or asphalt to prevent rust.

between them until they are tight and the holes are all in a line, and the pin F, can be inserted. The shackle is then put in place, and the pin and key adjusted, when the stone will be ready for lifting.

The pin lewis is simply used by inserting the pins in holes sunk dovetail fashion in the top bed, on a line drawn down the middle of the top bed and parallel to the arrises. Should the stone be very large or long, the links shown on the pin lewis are cut off and a good stout 2 or 2½ in. chain used by passing it through links and the ring here represented. When raising, it is usual for setters to first test whether the lewises are carrying safely by raising the stone a few inches up from the ground and standing on the

stone, thus testing it above the actual weight of the stone itself and ensuring its reliability

Modern steel derricks replace the type just described for all large work. These derricks are operated by steam or electric hoists.

Another form of lewis is shown in figs. 5,581 and 5,582. It will readily be seen that it is a very quick operation to set

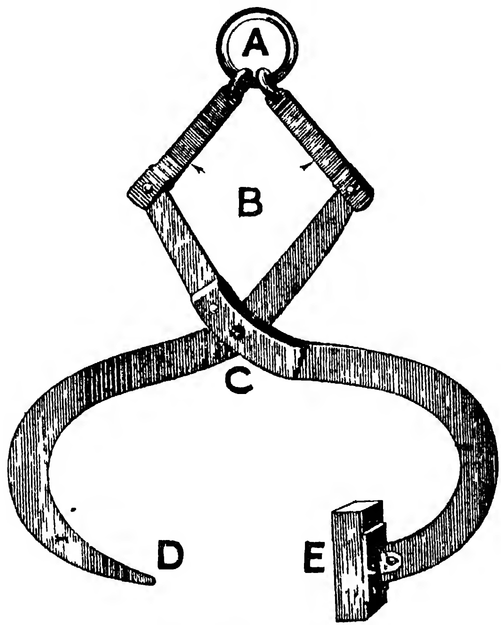


FIG. 5,581.—Stone setter's grab. *This is a system* of curved levers or bent wrought (Norway) iron forged to the shape shown and much resembling in their form and action a pair of scissors. To the left at D is forged a point which is intended to fit into a shallow hole cut in the back of the stone and in the center; this being rough it does no injury, but the face of the stone being finished must be preserved unmarred, so on this side the right arm E a wooden block is fastened working on a loose pin which adapts itself to the shape or surface of the stone, this face being usually covered with a piece of soft carpet. It will be easily understood that when the ring A is lifted by the hook and ropes attached to the derricks the strain will pull the connecting bars B B upwards and these will in their turn by pressure, while acting on the pin C as a fulcrum force the point D and the block E toward each other, thus holding the stone in an inflexible grip.

this tool in the stone or to remove it. And it can be easily made by any machinist blacksmith; it is easily reproduced.

The next appliance used is the "banker" or bench, which is a low heavy bench of oak or other hard wood on which the setter places his blocks of stone when fitting them on the job.

On the larger works this is generally set on the floor of the shed over the sidewalk, when the work is carried above the first story, and the stones are hoisted thereon, as it is much more convenient when the steel frame is well ahead.

Besides being outside the building it gives room inside for the bricklayers to back up the ashlar, etc., as it is set. The "banker" averages from three to six feet in length according to the sizes of the material.

When the conditions are such that a lewis cannot be used, a grab as shown in fig. 5,584 is used. Grabs are made to lift from 1,500 to 6,000 lbs.

A still further method of lifting stones of too large dimensions for the capacity of the above described tools, is the rope and hooks, or chain and hooks, which consist of a closed chain or rope passed through the rings of two or more large wrought iron hooks, which reach over the ends or sides of the stone and have their points let into holes similar to the point D, of the "grab."

This method is much in vogue when setting long heavy sill and dentel courses, the holes being sunk in the ends of plum joints as they do not show. It is also applicable to stones of large area, such as platforms, cornices of stoops and such like.

The hand tools of the setters are, as may be expected, those of the stonecutter, as shown in the accompanying illustrations.

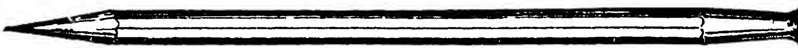
They are used with the mallet, fig. 5,591, which is turned out of greenhart or *lignum vitae* wood, and is swung with the right hand; the stonecutter or setter regulating the finish of the work with his left according to the angle

at which he holds the pitching tool or drove These chisels are made in the following sizes of the best steel, and are indispensable to the setter:

Pitching tools,	1 in steel,	2 to $2\frac{1}{2}$ ins	wide	
" "	$\frac{7}{8}$ " "	2	"	"
" "	$\frac{3}{4}$ " "	$1\frac{1}{2}$ to 2	"	"
" "	$\frac{5}{8}$ " "	$1\frac{1}{4}$ to $1\frac{3}{4}$	"	"
" "	$\frac{1}{2}$ " "	1 to $1\frac{1}{2}$	"	"
" "	$\frac{3}{8}$ " "	$\frac{1}{2}$ to $\frac{3}{4}$	"	"

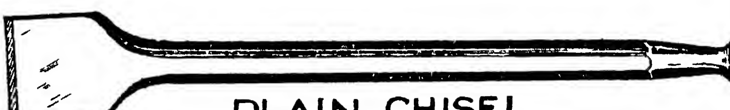
3 in lime stone droves
$3\frac{1}{2}$ " " " "
4 " " " "
5 " " " "

Wider tools are made to order

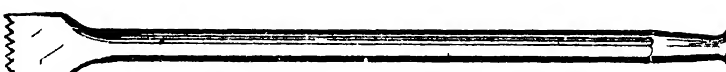


POINT

SPLITTER



PLAIN CHISEL

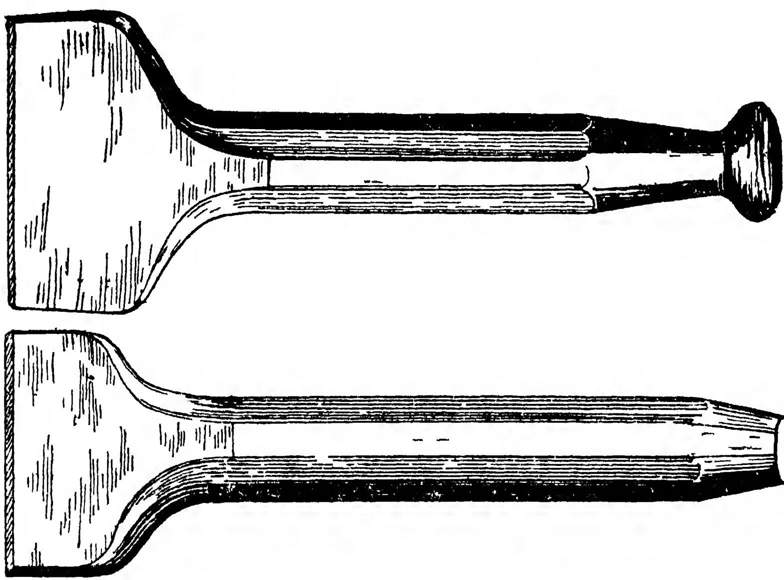


TOOTH CHISEL

FIGS 5,585 to 5,588 —Stone cutters marble tools Fig 5,585 point fig 5,586, splitter, fig 5,587, plain chisel fig 5,588 tooth chisel

NOTE The hand hammer and mallet are used for chiselling hard and soft stones respectively The pitching chisel is used to make a well defined edge on the face of a stone and the point for finishing a surface The chisel and tooth chisel are used for cutting drafts or margins on the face of stones but the latter is used only on marbles and sandstones The splitting chisel and plug are used for splitting stratified and unstratified stone respectively In architectural carving a variety of chisels of different forms are used for most of which no specific name exists For extensive operations machinery replaces many of the hand tools above described The chief ones are the saw and planer the latter being a machine very similar to a metal planer By simply changing the cutting tool a great variety of surfaces may be formed A certain amount of hand work however, always remains to be done on nearly all stones —*Siebert & Biggin.*

Tools of a special form for the cutting of marble, like those shown in the accompanying illustrations, are much used by the setter, as they are lighter, the material being softer and easier to cut, and a lighter size of mallet is applied. These tools are made from ¼ to ½ inch in thickness, the heavier being from ⅝ to ⅞ inch, and of steel, though the heavier sizes are not much in demand.



Figs. 5,589 and 5,590. Pitching tool and lime stone drive. These are used with the mallet shown in fig. 5,591.

Trimmings.—This includes mouldings, belt courses, caps, sills and other cut stones (except ashlar) used for ornamental purposes. The faces of stones used for such work may be pitched off, but all washes, soffits, etc., should be cut or rubbed. The tops of all cornices, belt courses, etc., should have an

outward pitch from the walls for obvious reasons. Window sills should have a deep cut in them to keep the walls below from becoming discolored by dirt washed off the sills by rain.

Stains on Stone Masonry.—Any stone may change its color

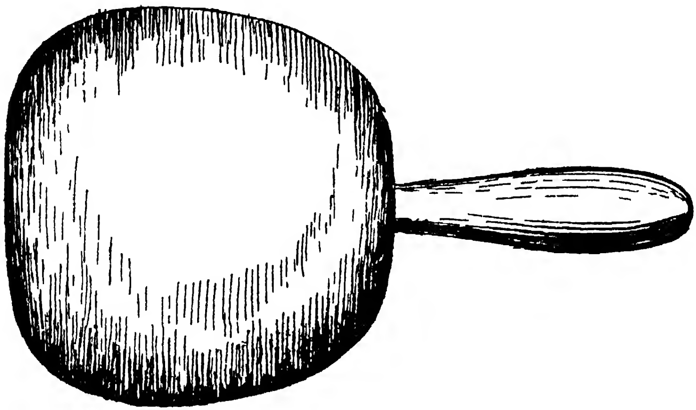
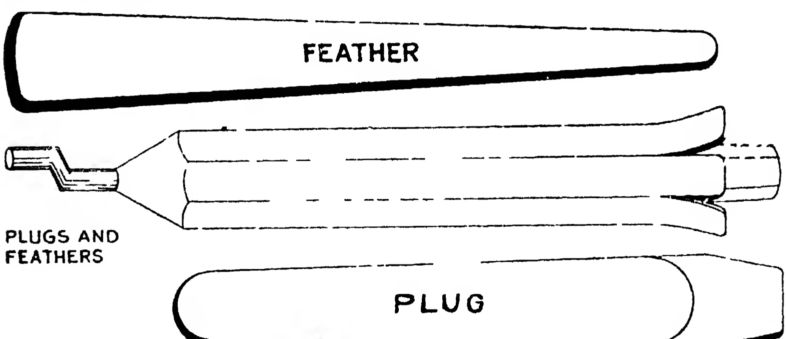


FIG 5,591 — Stone cutter's mallet



FIGS 5,592 to 5,594 —Plug and feathers The plug is a steel wedge, and the feathers are made of half round malleable iron *Used* for splitting *In splitting,* a row of holes is part made with a drill and in each hole two feathers are inserted, then the plugs are lightly driven in between them The plugs are then gradually driven home until the stone splits

somewhat in weathering, but this will be in the way of a mellowing of tone, and will give no unsightly blotches. This is proved by the natural exposure of the rock in the quarry. Where there is staining in the walls of a building, it can safely be set down to faults in the setting, or to some cause extraneous to the stone itself.

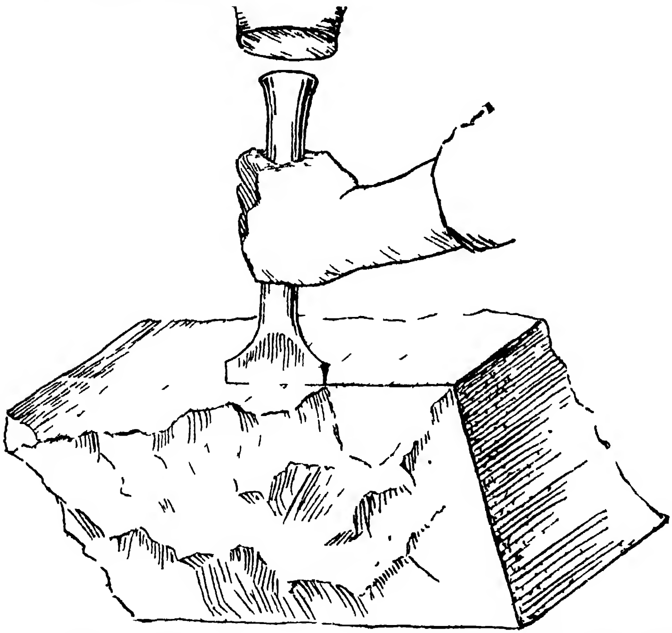


FIG 5,595 —Method of using the pitch chisel in chipping a stone so as to give level surfaces or *pitches* wherewith to set adjacent stones true by each other

The most prolific source of trouble is, of course, the cement that is used in setting the stone. Ordinary Portland cement will badly stain almost any stone. Various so-called "non-staining cements" are widely heralded, but it is the universal experience of stonemen that little dependence can be placed on these.

Architects will specify very particularly that stone be set in cement mortar and think that they guard against all trouble if they require the back and sides of the stone to be coated with waterproof paint Undoubtedly a good paint is much protection, but the difficulty is to coat the beds and joints of each stone clear to the face A narrow strip left unpainted will permit the carrying of the discoloring moisture from the cement to the face of the stone by capillarity

Stone Cutting.—In stone cutting the first operation is to form the joints of one surface, and from these all the other bonding planes of the finished stone are derived. A line is

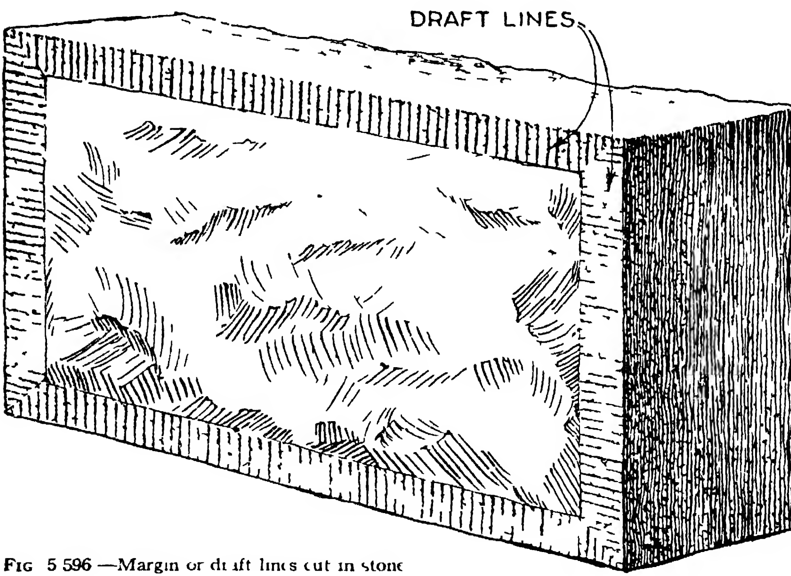


FIG 5 596 —Margin or draft lines cut in stone

first scribed around the stone to represent the edge and the stone chipped or pitched off to this edge as in fig. 5,595.

The next step consists of cutting a *margin* or *draft lines* as shown in fig. 5,596. These are cut with a chisel on the

soft stones and with an axe on granite. In stone cutting patterns, templates and bevels are used to direct the cutting.

Patterns show the forms of plane or of developable surfaces, and in the latter case are made of flexible material. Templates give the forms of required edges or other distinguishing lines of a surface. A pattern is used to lay out the relative position of the edges, whereas a template defines any particular edge or edges. Bevels show the diedral angles between surfaces. The common carpenter's square is a special form of bevel, and the straightedge a special form of template.

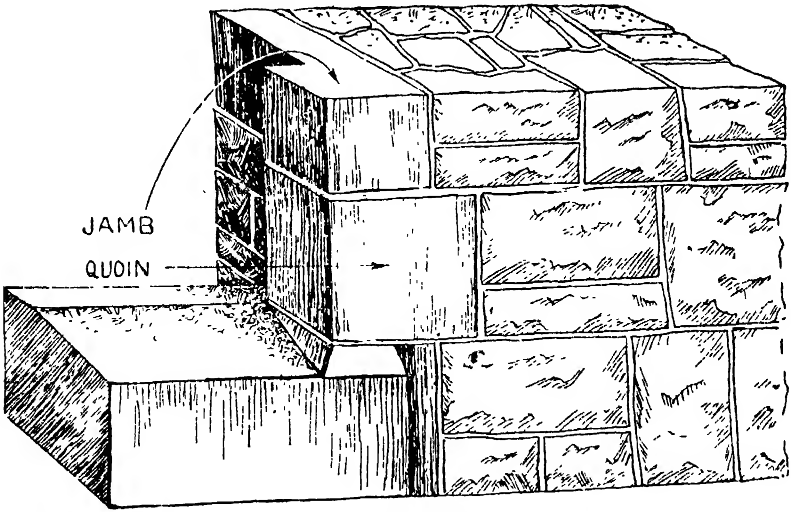


FIG. 5,597.—Quoins and jambs. These are often dressed differently from the other stones for appearance.

Some builders believe that all mortar staining can be avoided by using lime mortar without any cement; others claim the addition of 20 to 25% of hydrated lime added to white Portland cement will also be non-staining.

If the most delicate stone be set in mortar of either as above, and the back of the stone plastered with the same mortar, it positively will not stain. There are other ways in which stone may be stained—by the drippings from concrete floors or roofs. In such cases the discoloring moisture runs

down the face of the stone, and no painting of the back or beds can afford any protection The utmost care in superintending the construction is the only safeguard from this disfigurement.

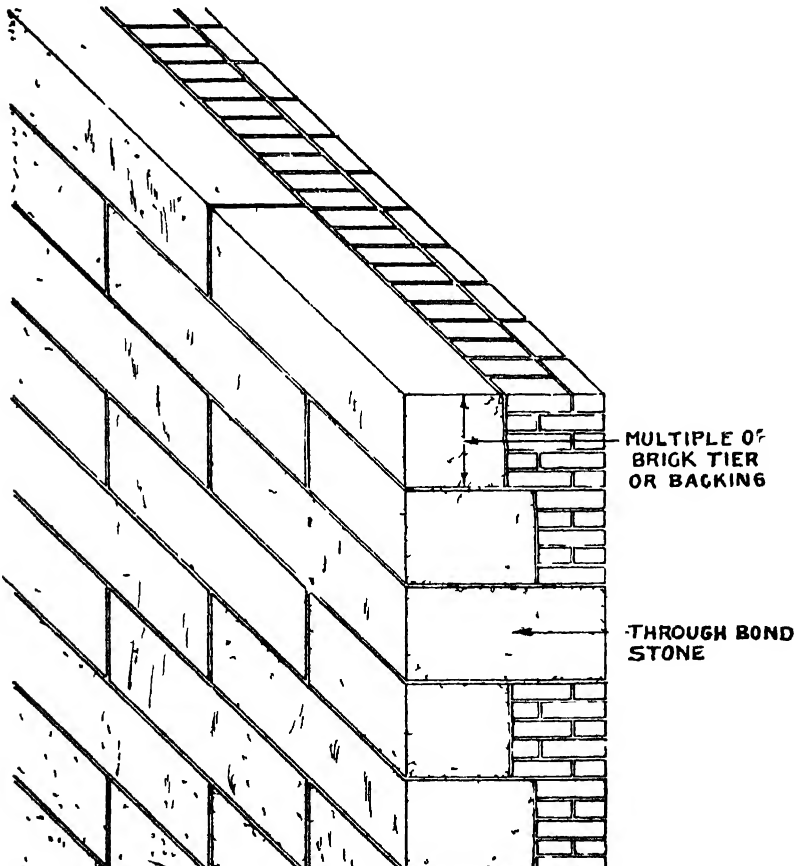


FIG 5,598 —Ashlar with brick backing *The backing* should be carried up progressively with the ashlar The vertical thickness of the ashlar should be a multiple of the brick plus joints as shown The horizontal width of the stones should vary to obtain bond and there should be one through bond stone to every 10 sq ft of wall

Cement stains cannot be eradicated by any wash or other treatment. Fortunately, they are apt to bleach out in time under the influence of the sun and the weather.

The stone setter, anxious to leave a building in spick and span condition, may suggest that it be washed down with muriatic acid. This should never be permitted. The acid may take out some of the stains for the moment, but it burns the surface and eventually will discolor even those portions that escaped the original staining.

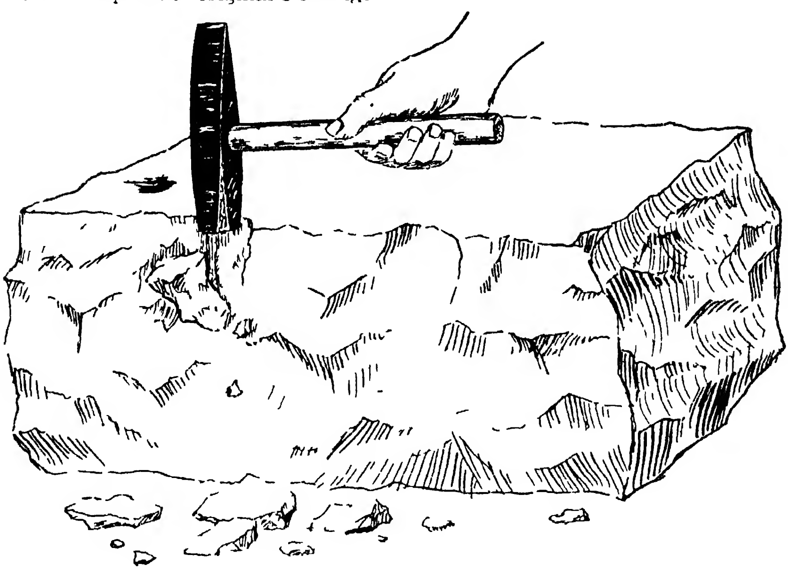


FIG. 5,599.—Operation of chipping stone for rough ashlar with hammer.

There was a time when scrubbing with wire brushes was permitted, but this has generally been discarded, since its bad effects have been recognized. It is impossible to use wire brushes without leaving a coating of iron on the surface of the stone, and this is bound to leave a worse stain than it corrects.

The sand blast is sometimes employed, but generally for old buildings that have become discolored from smoke and soot. This method should always be discouraged. The sand strikes the stone with a tremendous impact. It destroys the "skin" which forms on the surface of the stone

by deposition of mineral ingredients on the evaporation of the interstitial water. It also stuns the grains or crystals of the stone and tends to hasten the weathering.

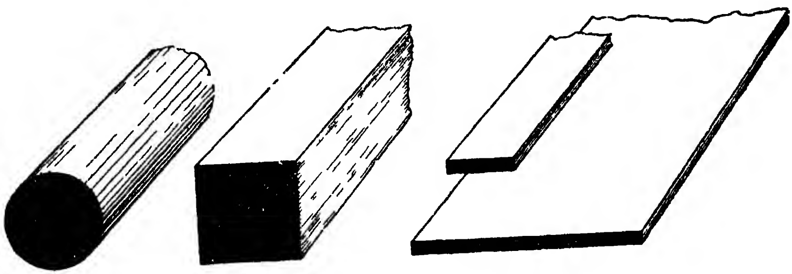
The very best treatment of stone to remove smoke, soot, dirt, mortar, etc., is a simple washing. A recipe that is recommended by stonemen of the widest experience is as follows: Prepare a wash of soft water and about one and a half bars of common laundry soap. Boil until the soap has been thoroughly dissolved. Add a fine, clean, gritty sand (white preferred) and mix to about the consistency of putty. While mixing add about five tablespoonfuls of ammonia per bucket of water. With this preparation scrub the surface with a stiff scrubbing brush. Wash down with a stream of water from a hose, and then go over it again with scrubbing brush.

While any building may need a cleaning, a great deal of the staining could be avoided if more care were taken. The rust from improperly protected iron or steel and the verdigris from copper or bronze sheathing have disfigured many a fine structure.

CHAPTER 100

Steel Construction

Structural Shapes.—The steel used in a building of steel construction is in the form of single pieces or combinations of



FIGS. 5,600 to 5,603.—Structural shapes. Fig. 5,600, round rod; fig. 5,601, square rod. Fig. 5,602 flat; 5,603 plate. Sizes: rounds $\frac{1}{4}$ to [illegible]$\frac{}{16}$ increasing by $\frac{1}{64}$; squares $\frac{3}{16}$ to $5\frac{1}{2}$ increasing by $\frac{1}{64}$, $\frac{1}{[illegible]}$ and $\frac{1}{8}$ according to size; flats width $\frac{1}{4}$ to [illegible], thickness, $\frac{3}{16}$; plates thickness $\frac{3}{16}$ to 2, width 6 to [illegible]6 ins.

two or more pieces to which the name "structural shapes" is given.

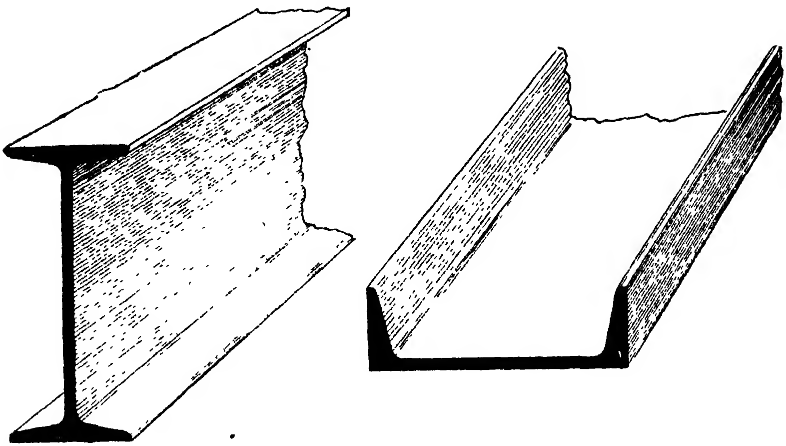
In the manufacture of structural shapes when the ingot is taken from the soaking pit and "cropped," it is placed on the table of the rolls, or *blooming table*. This table consists of a number of cylinders placed close together and made to revolve either forward or backward as desired. The table moves the ingot to the rolls where it is rolled through an opening but slightly smaller than the ingot itself. The ingot comes out on the other side longer than it was before, and of uniform section throughout its entire length. Here it is automatically moved to one side and the cylinders of the

rolling table being put in motion, the steel goes to another set of rolls and is again reduced in sectional dimensions.

The first few passes generally reduce the ingot to a rectangular or square section.

The steel is then moved sidewise to a different roll opening in turn. Each of these shapes of the steel is something approaching its final shape and at the last pass, what was an ingot only 63 ins. becomes a rail, plate or other structural shape 20 to 120 ft. or more in length.

In cases where the number of passes is great, instead of two rolls, three or more are used. The blooming table is so arranged in this case that it



FIGS. 5,604 and 5,605 —Structural shapes 2. Fig 5,604, I beam; fig. 5,605, channel ***Sizes*** (standard shapes): depth of beam 3 to 24, width of flange 2.33 to 7.25, depth of channel 3 to 12, width of flange 1.41 to 3.42 ins.

may be raised or lowered, thus carrying the steel to the upper set after it has passed through the lower one.

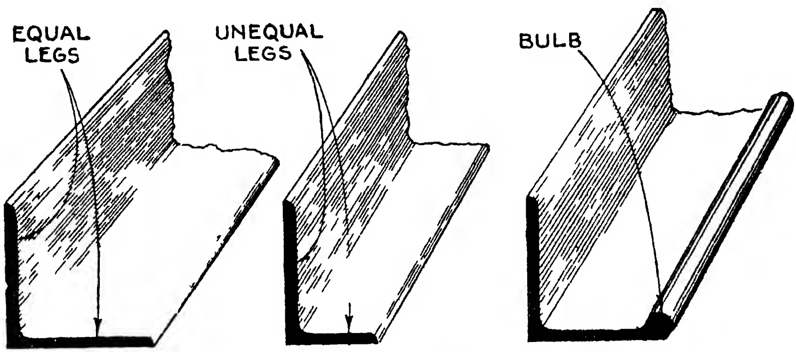
There are a multiplicity of shapes regularly manufactured which may be tabulated as follows:

1. Rods.

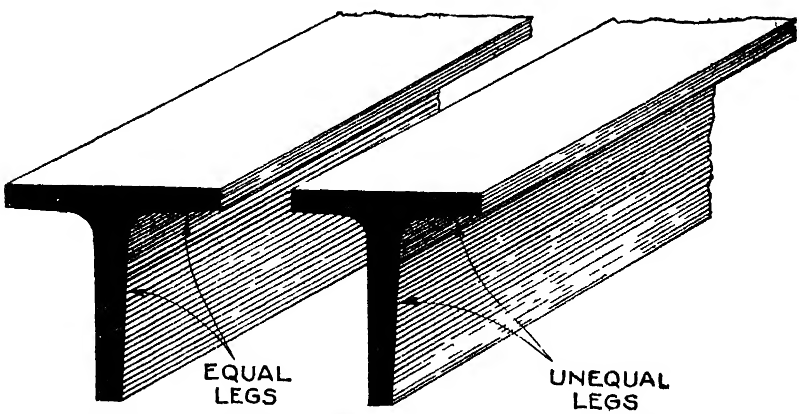
    a. Round
    b. Square

2. Flats.
3. Plates.
4. I Beams.

   a. Standard
   b. Special



Figs. 5,606 to 5,608 — Structural shapes 3. Angles. Fig. 5,606 equal leg angle; fig. 5,607, unequal leg angle; fig. 5,608, bulb angle. **Sizes** (standard equally) $1\frac{1}{4} \times 1\frac{1}{4}$ to $3\frac{1}{2} \times 3\frac{1}{2}$ ins.



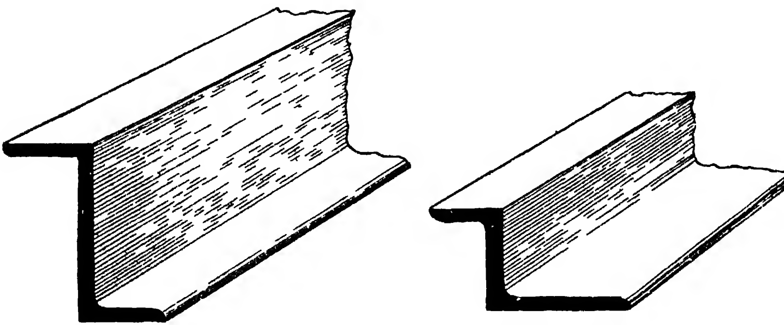
Figs. 5,609 and 5,610 — Structural shapes 4. T bars. Fig. 5,609 equal legs; fig. 5,610, unequal legs. ***Sizes*** (equal legs) 1×1 to $2\frac{1}{2} \times 2\frac{1}{2}$ ins.

5. Channels.

   a. Standard
   b Special
   c Ship

6. Angles.

   a Standard { equal legs / unequal legs
   b Special
   c Bulb



FIGS 5 611 and 5 612 —Structural shapes 5 Z bars Fig 5 611 standard fig 5 612 special *Sizes* (standard bars) $2\frac{3}{4} \times 3\frac{1}{16} \times 2\frac{3}{4}$ to $3\frac{1}{2} \times 6 \times 3\frac{1}{2}$ ins

7. T Bars.

   a. Equal legs
   b. Unequal legs

8. Z Bars.

   a. Standard
   b Special

9. Plates.

   a Trough
   b Corrugated
   c Checkered

Structural shapes for buildings consist usually of I beams, channels, angles, Z bars and plates, used either as single members or in combination to form compound or built up members. The Z bars are now seldom used for columns or other structural work in buildings.

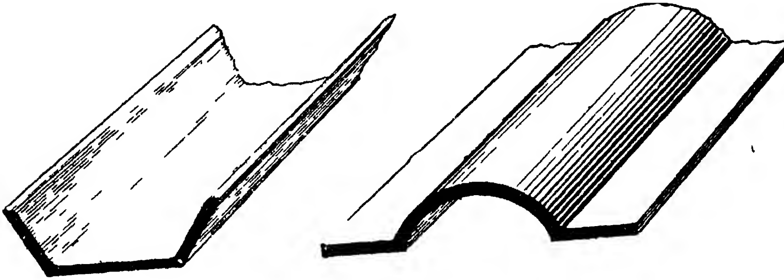
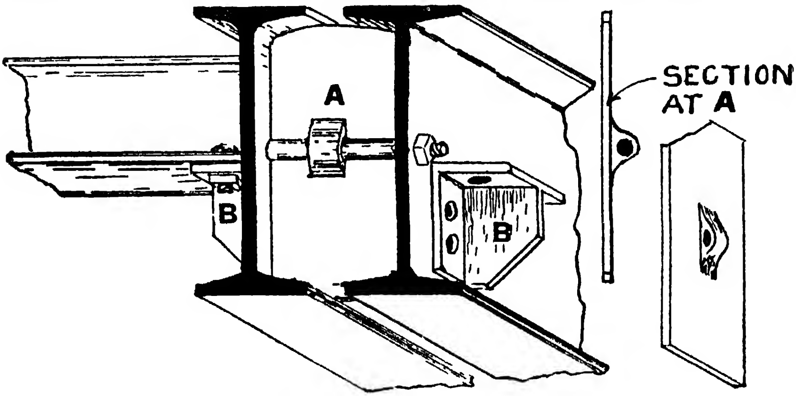


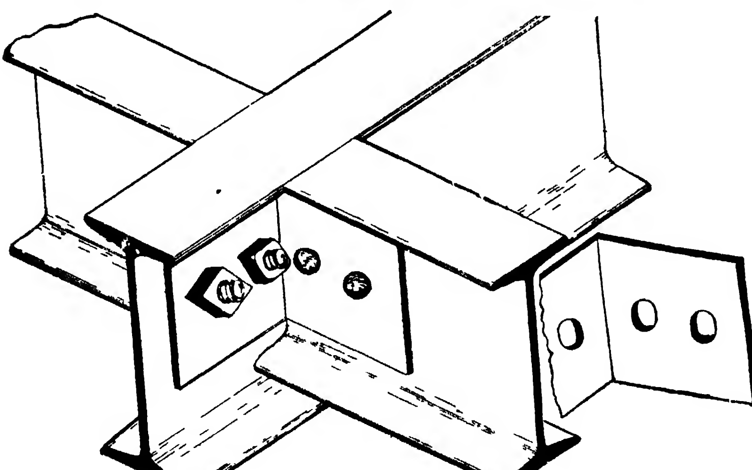
FIG. 5,613 to 5,615. Structural shapes 6. Plates. Fig. 5,613, trough plate, fig. 5,614, corrugated plate, fig. 5,615, checkered plate.

Beams as Girders.—In some cases two or more beams may be bolted together side by side to form a girder, in which case cast iron separators, as shown in figs. 5,616 and 5,617, with bolts should be used to hold the various members together. Separators should be placed at each end of the girder, as in fig. 5,618, and at points of concentrated loading, and for

uniform loading should be located at distances apart not greater than twenty times the width of the smallest beam flange, in order to laterally support the upper flanges which are in compression and prevent their failure by buckling. The separators



FIGS 5,616 to 5,618 —Separator for I beam and assembly of two beam girder.



FIGS 5,619 and 5,620 —Connection angle for I beam and its application

should preferably fit closely between the beam flanges so as to unite the beams forming the girder and thereby cause them to act together in resisting the load.

Connection Angles.—When beams are coped or fitted together at right angles, connection angles are generally used

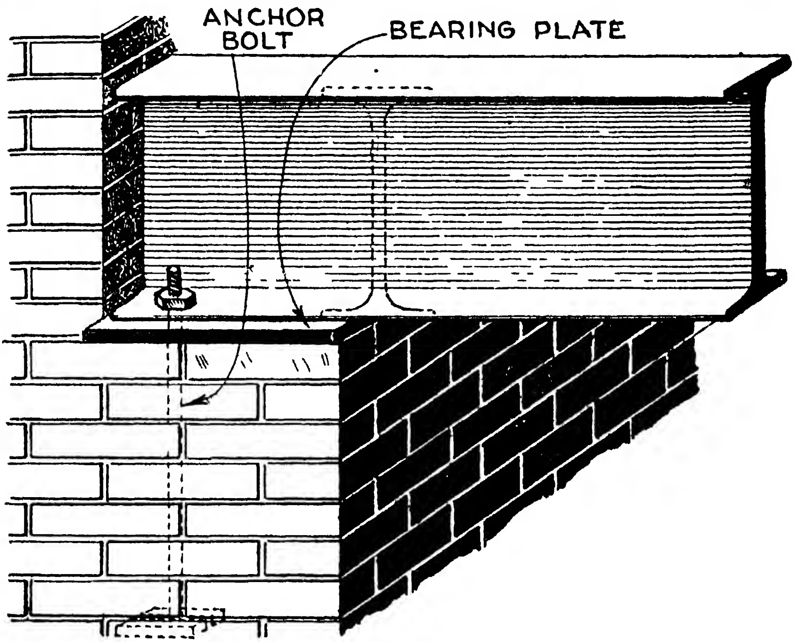


FIG. 5,621 —I beam on bearing plate and anchored with anchor bolt

as shown in figs. 5,542 and 5,543. Beams may be fitted together thus with flush tops or bottoms or in intermediate positions as required in cases where the girder or trimmer beam is the larger. In cases where the girder or trimmer beam is the smaller, special stirrups or other connections are required.

Bearing Plates and Anchors for Beams.—Shapes used as beams resting on masonry walls or piers will generally require bearing plates of steel or their equivalent, set in or upon the masonry to properly distribute the load thereon with due re-

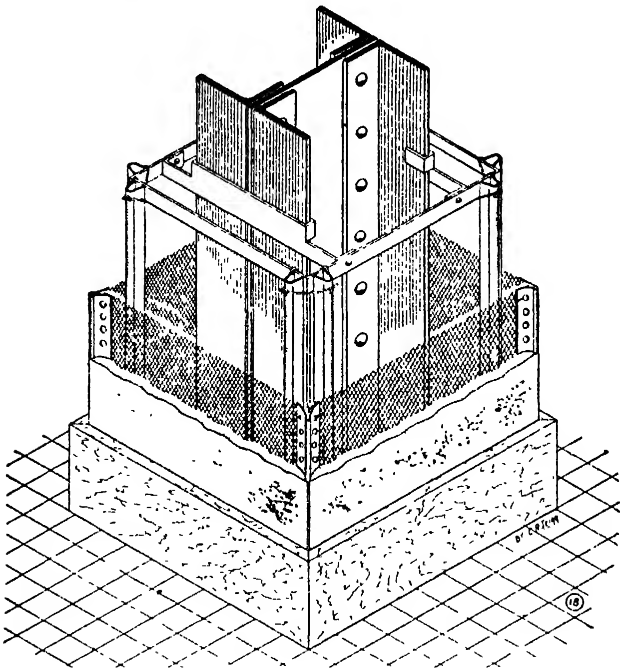
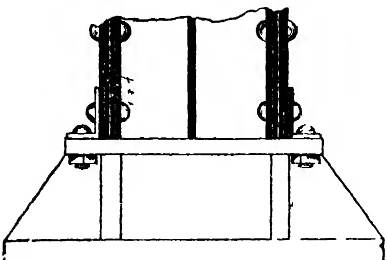
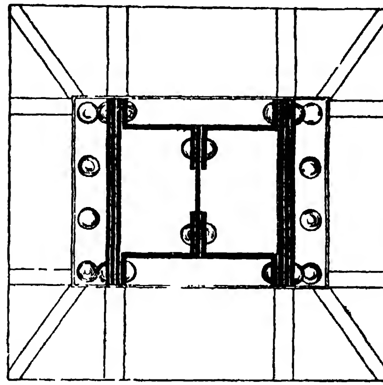


Fig. 5,622.—Column protected with expanded metal lath and cement plaster.

gard to the allowable safe pressures for the class of stone work or brick work in question.

The allowed pressure per square foot for first class brick work should not exceed eleven tons and for ordinary masonry eighteen tons. Anchors are common in building construction:

the split anchor bolts, with or without wedges, are mostly used for bridge work and column foundations. Fig. 5,621 shows

Figs. 5,623 and 5,624.—Base and column made up of Z bars, plates and angles

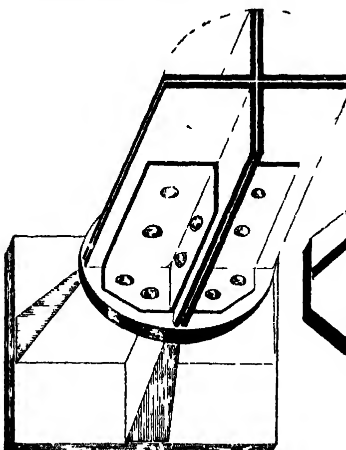
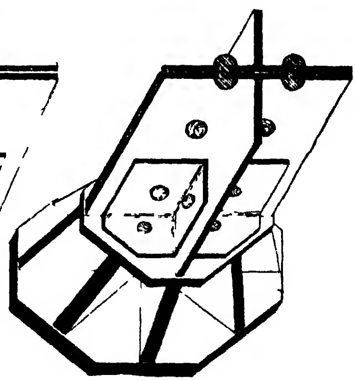
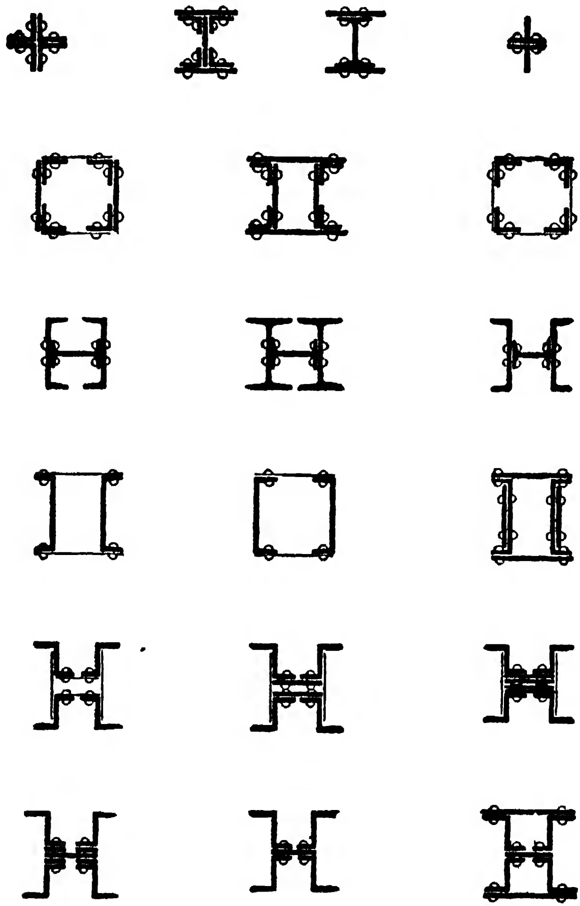



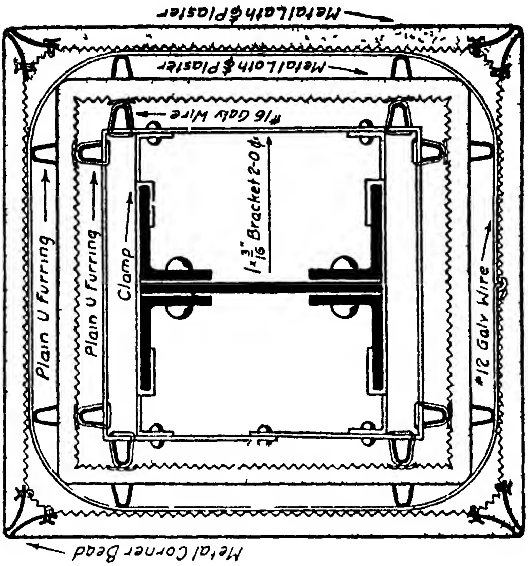
Fig. 5,625.—Base and column made up of angles.
Fig. 5,626.—Base and column made up of I shape.

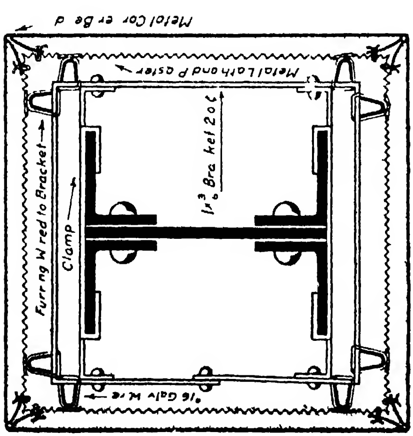
application of split anchor bolt for anchoring an I-beam in brick wall.

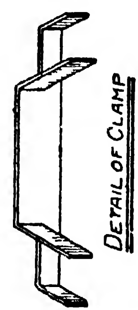
BUILT COLUMN SECTIONS

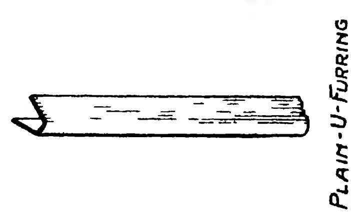


FIGS 5,627 to 5,645 --Various columns formed by building up combinations of the structural shapes symmetrically arranged









Figs 5,646 to 5,649 —Single and double all protection and details

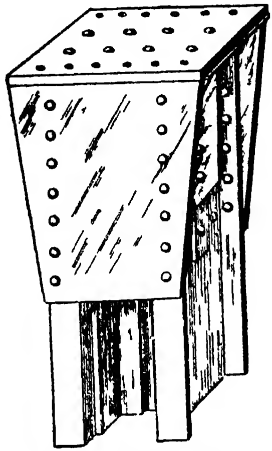
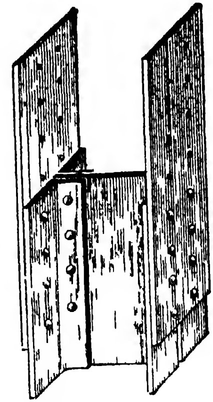
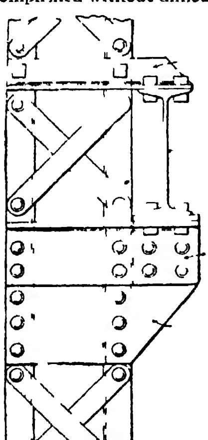
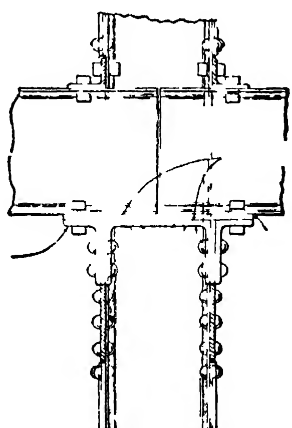



FIG 5 650 —Top of angle plate column The top or cap plate should be well supported by shear plates as shown

FIG 5 651 —Column joint or splice *The splice* should be designed to give the column the full strength of the uncut section with respect to stiffness against lateral deflection Since the splice is near the floor beam connections where the column is braced laterally this can be generally accomplished without difficulty

FIGS 5 652 and 5 653 —Eccentric connection of beam to latticed column Such connections require extra rivets in addition to those required for the direct lead in order to resist the tendency to rotation due to the eccentricity

OPEN TRUSS STEEL JOISTS

This term is given to a lightweight member produced by a different method than the rolled structural shapes. By definition a *truss* is an assemblage of members such as beams, bars, rods and the like, so combined as to form a rigid framework, that is, one which cannot be deformed by the application of exterior force without deformation of one or more of its members.

Properly a truss should be in the form of a triangle or a combination of triangles, because this is the only polygon whose shape cannot alter without changing the form of its sides. When so designed, the only strains in the members will be those of tension and compression. A long truss is often called a girder.

Trusses are made of either *wood* or *steel;* wood trusses are commonly adopted for light construction, such as in home or similar uses, whereas steel trusses are most frequently used in heavy construction, as in apartment dwellings, garages, factories and the like.

Various Truss Types.—As previously stated the members of a truss divide it into a number of triangles, and although it is possible to arrange the triangles into a great multiplicity of truss types, it has been found that only a few selected types such as those shown in figs. 5,654 to 5,675 are suitable for use in building construction.

In the diagrams, the members indicated by heavy lines normally carry compressive stresses, whereas the light lines normally carry tensile stresses for vertical loads. In most cases the compression members are the shortest members in the truss, while the tension members, shown by the light line, are the longest. This results in a great saving of material, because of

the fact that a compression member requires a greater sectional area for a given stress than a tension member.

Sometimes the top chord of roof trusses are slightly sloping in one or two directions for drainage, but this does not change the type of truss. Fig. 5,656 and 5,659 are typical examples. The necessary member of sub-divisions or panels depend upon the length of the span and the type of construction. Terms used in connection with trusses are as follows:

Bottom chord is a member which forms the lower boundary of the truss.

Top chord is a member which forms the upper boundary of a truss.

Chord member is a member which forms part of either the top or bottom chord.

Member is the component which lies between any two adjacent joints of a truss, it can be one or more pieces of structural material

Webb member is the component which lies between the top and bottom chord.

Joint is any point in a truss where two or more members meet and is sometimes called a "panel point"

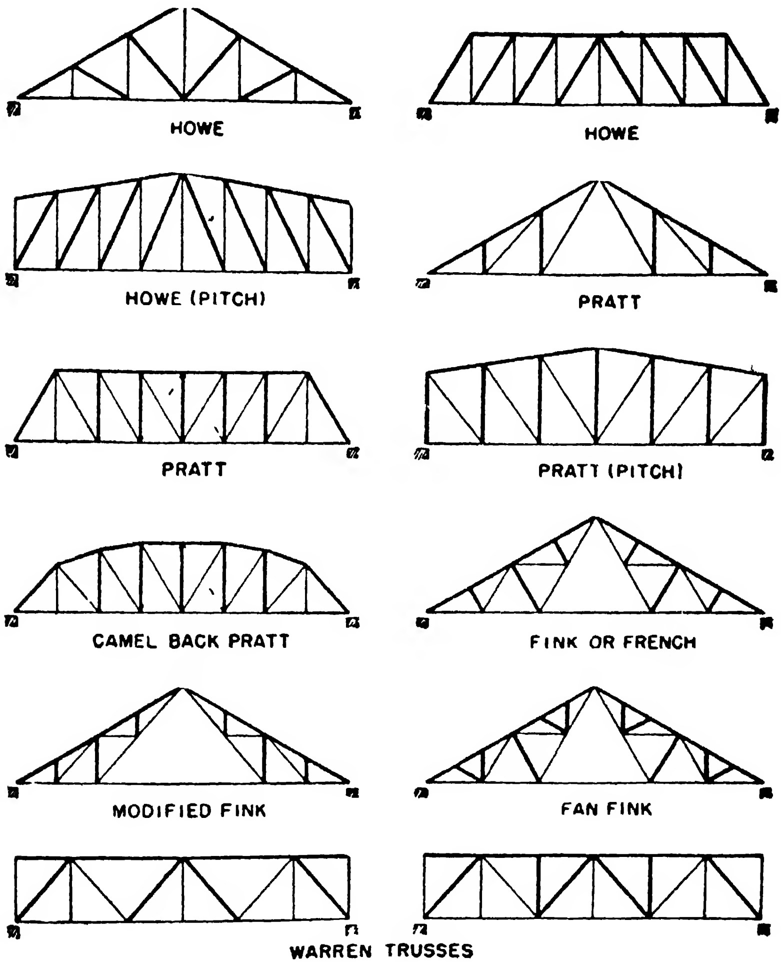
Panel length is the distance between any two consecutive joint centers in either the top or bottom chords

Pitch is the ratio of the height of truss to the span length.

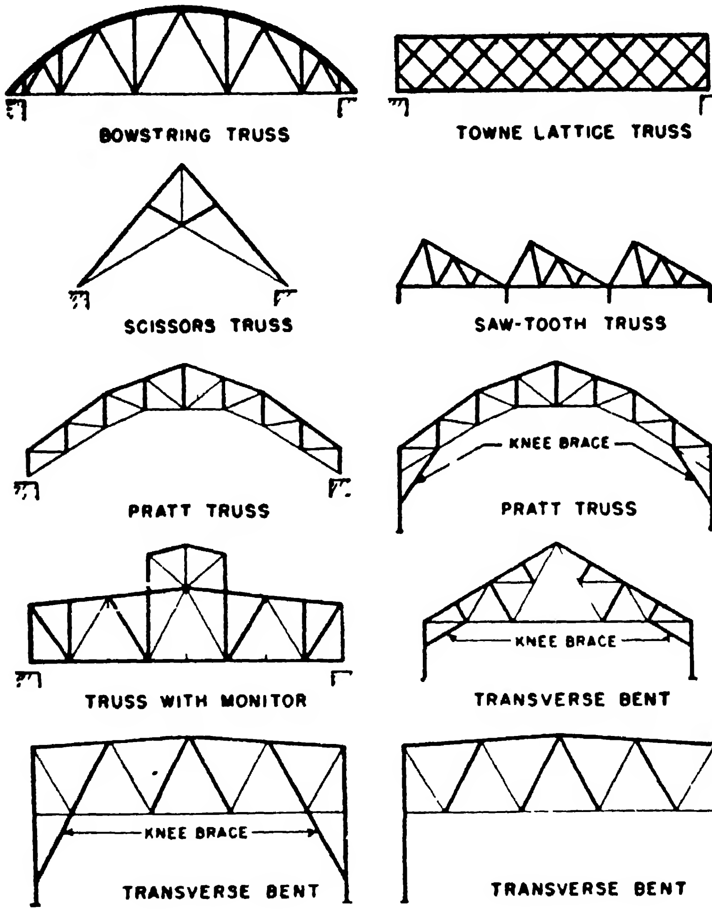
Height of truss is the vertical distance at mid span from the joint centers at the ridge of a pitched truss, or from the center line of the top chord of a flat truss to the center line of the bottom chord.

Span length is the horizontal distance between the joint centers of the two joints located at the extreme ends of the truss.

Construction and Use.—While open truss steel joints were primarily developed to provide a more rigid, fire resistant, economical and light weight floor construction, their use through the years has proven their dependability in all types of construction. These joists are designed according to the best engineering practice and offer many construction advantages.



Figs. 5,651 to 5,665 Showing construction principles of various types of trusses used in construction work. One of the most popular steel trusses for floor construction and as purlins for roof construction is a Warren truss having top and bottom chords of wide tee shaped members and a plain continuous web member. Other popular trusses used in all types of roof construction are the Howe and Pratt types.



Figs. 5,666 to 5,675.—Illustrating various types of trusses used principally in roof and bridge construction.

Fundamentally the open truss steel joists of the ***Truscon*** type (which are the types illustrated in this chapter) is a ***Warren*** truss having top and bottom chords of wide tee-shaped members and a plain continuous web member. The bottom chord is continuous from end to end of joists and bent up at the ends to form the bearings. Steel joists are fabricated by means of electric machine welding under pressure, making positive connections at all joints.

The underslung design of the bearing permits maximum headroom under the supporting girders. The open web allows for the passage of pipes and conduits in any direction.

Truscon Steel Joists for Floor and Roof Construction

Where *steel joist construction* is specified, it shall be understood to mean that type of construction in which decks or top slabs are supported by Truscon O-T (open truss) steel joists spaced not more than 24 ins. on centers in floors or 30 ins. on centers in roofs.

Joists. -These shall be made of hot rolled steel shapes in the form of a Warren truss having top and bottom chords of single T-shaped members and a plain round continuous web member. The bottom chord shall be continuous from end to end of joist and bent up at the ends to form the bearings. Steel joists shall be fabricated by means of electric machine welding under pressure making positive connections at all joints.

All steel used shall conform to the *American Society for Testing Materials* Standard Specifications for Steel for Bridges and Buildings Designation A-7 of latest adoption.

All steel joists shall be spray painted with one shop coat of asphalt base metal protective paint.

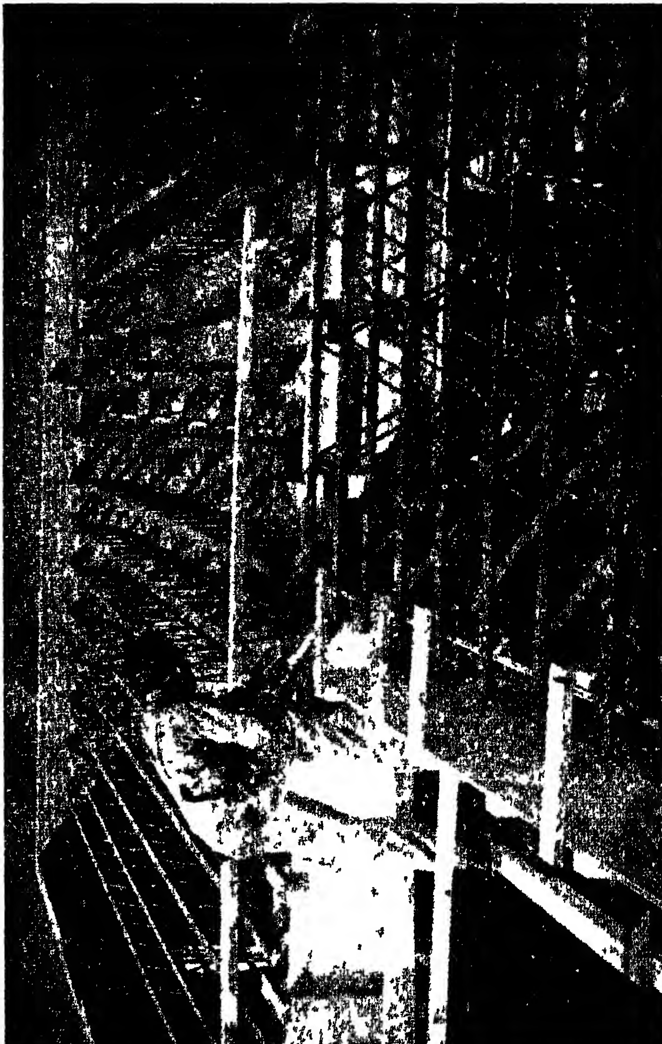


FIG 5 676 —Typical installation of open truss steel joists

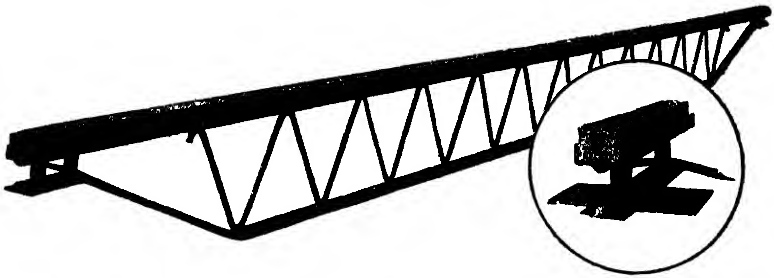


Fig. 5,677.—Illustrating typical open truss nailer joists and end detail with bearing plate for bolted connection.

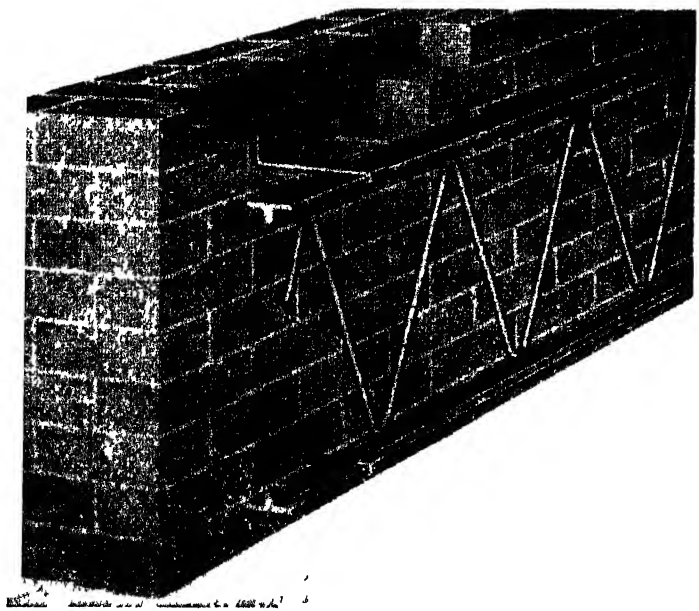


Fig. 5,678. Showing typical open truss steel joist installed on masonry wall. Steel joists parallel to masonry walls should have their top and bottom chords anchored to the wall by means of special wall anchors where each row of bridging occurs. The bent end of each anchor should be first attached to the joist and the other end bent up and built into the masonry wall as illustrated.

Design.—The design and details of all joists shall meet the requirements of the *Steel Joist Institute Specifications*. See pages 1,008 to 1,019.

Location and Spacing of Joists.—Steel joists shall be spaced not more than 24 inches on centers in floors or 30 inches on centers in roofs, except they may be used to support roof-decks, if not spaced over seven feet on centers and provided the deck is securely attached to the top chord to prevent any lateral deflection.

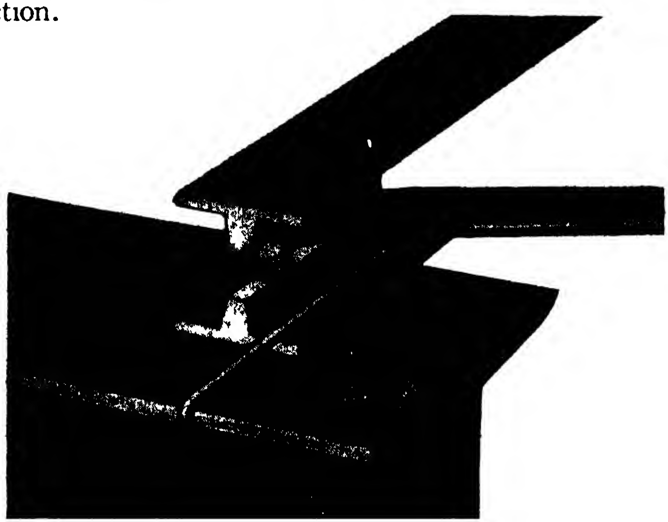


FIG 5,679 —Open truss steel joist installation where joist rests on a structural steel beam Ends of all steel joists resting on structural steel beams should be anchored thereto by means of special anchors The bent end of the anchor should be first inserted in the slot and the other end bent around the flange of the beam as shown

There shall be one typical joist spaced not more than four inches in the clear from each end wall or bearing wall parallel to the posts Structural steel tie beams shall not be used to take the place of joists unless architectural or structural plans indicate same are to be used as supporting members.

Where a partition is parallel to joists and the length of the partition exceeds fifty per cent of the joist span, an extra joist shall be provided under the partition or, if necessary, double joists shall be provided under the partition load. Where partitions extend over joists at right angles to same, the additional partition load must be included in computations as part of the dead load.

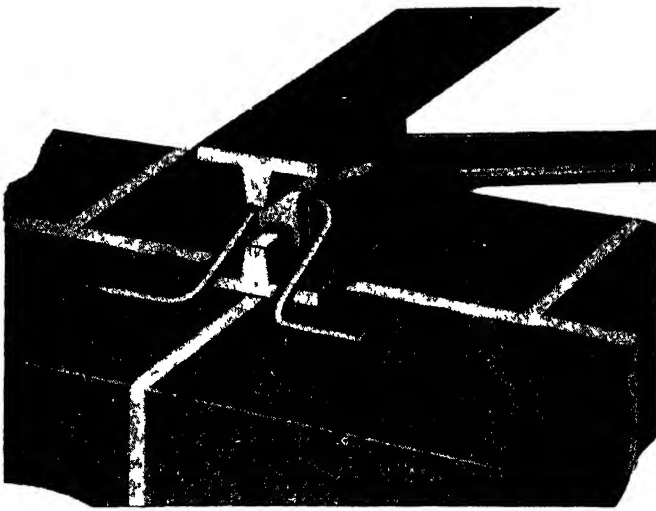


FIG. 5,680.—Open truss steel joist resting on masonry wall. Ends of every third joist resting on masonry walls should be anchored thereto by means of special wall anchors as illustrated.

Anchorage. The ends of steel joists shall extend a distance of at least four inches on concrete or masonry, and at least $2\frac{1}{2}$ inches on structural steel supports. Ends of every third joist supported on concrete or masonry shall be anchored thereto with a $\frac{3}{8}$ inch round wall anchor and at each end of every joist supported on structural steel shall be anchored thereto by means of a $\frac{3}{16}$ inch round beam anchor or two welds each one

FIGS 5 681 and 5 682 —Showing method of installing top and ceiling lath to open truss steel joists By means of special lath clips placed over the ribs of the metal lath the attachment to the joist is completed by simply pressing the clip lever with the thumb

inch long. Steel joists parallel to walls shall have each row of bridging chords anchored to the wall where each row of bridging occurs.

Span.—The span of steel joists shall not exceed 24 times the depth of the steel portion of the steel joist.

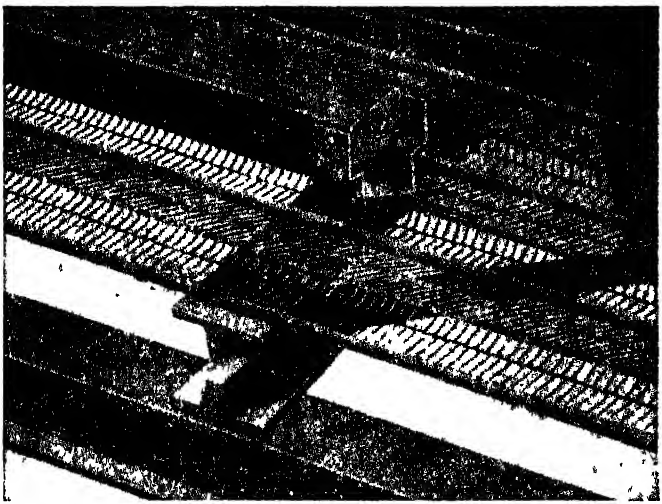


FIG. 5,683 Method of installing wood screeds to open truss steel joists used in floors. Where wood floors are required over concrete top slabs, special screed clips must be used to elevate the wood screeds so that the concrete can be properly worked under them. The screed clips must be attached to the top chord of the joists by means of lath clips.

Bridging. As soon as steel joists have been erected, bridging of any approved *Steel Joist Institute* type shall be installed between them before the application of construction loads. Bridging rows shall be spaced as follows:

Clear span 0 to 14 feet	One bridging row.
Clear span 14 to 21 feet	Two bridging rows.
Clear span 21 to 32 feet	Three bridging rows.

Ceilings.—Where fire resistive construction is required, steel joists shall be protected on the underside with a fire resistive ceiling consisting of plaster on metal lath and shall have a reinforced concrete or gypsum top slab, all as is necessary to provide the required degree of fire resistance, provided that

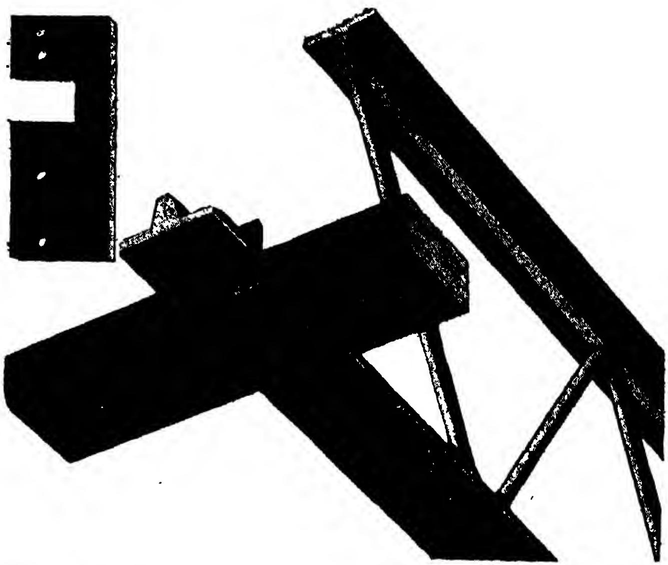


FIG. 5,684.—Showing furring clip for attaching wood screed to bottom chord of steel joist. Where wood screeds at right angles to the steel joists are required on the underside of the steel joists for ceiling construction, they can be attached by means of special furring clips as shown. These furring clips are made reversible to care for different thicknesses of wood screeds. Two clips are required at each intersection of screed and joist, and they should be attached on opposite sides of the screed as indicated.

where wood joist construction is permitted steel joists may have a wood nailing strip attached to the top chord and a wood floor may be used, and provided further than where steel joists are used in places where unprotected wood joists are permitted no ceiling protection need be provided. Where directly

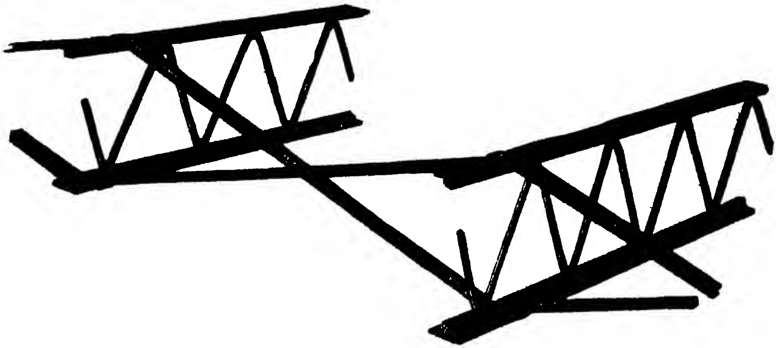
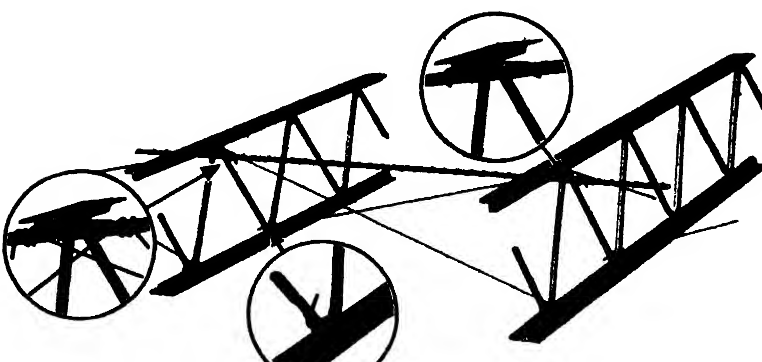


FIG 5,685.—Showing bridging method for open truss steel joists. This bridging method popularly termed *strut bridging* is very popular and easy to install. It is made of ¾ inch box channels and cut to lengths to meet the exact spacing of the joists. This bridging holds the joists in a vertical plan, assuring accurate spacing and distribution of loads by acting in both tension and compression as illustrated.



FIGS. 5,686 to 5,689 —Showing underchord rod bridging in open truss steel joists. This type of bridging is very effective and is easily installed. It is very practical and will permit of slight variation in joist spacings as is frequently necessary in order that joists can be spaced to avoid interference with bolt and rivet heads in supporting members, vent ducts, soil pipes, etc.

attached ceilings occur, ceiling extensions shall be provided at the ends of the steel joists.

Metal ceiling lath for directly attached ceilings shall be ⅜ inch rib lath weighing 3.4 lbs. per square yard for joist spacing up to 30 inches. The rib lath shall be placed under the joists with the rib up and at right angle to the joists. Ceiling lath shall be attached to the bottoms of the joists by means of lath clips spaced 8 inches apart, placed over the ribs of the lath.

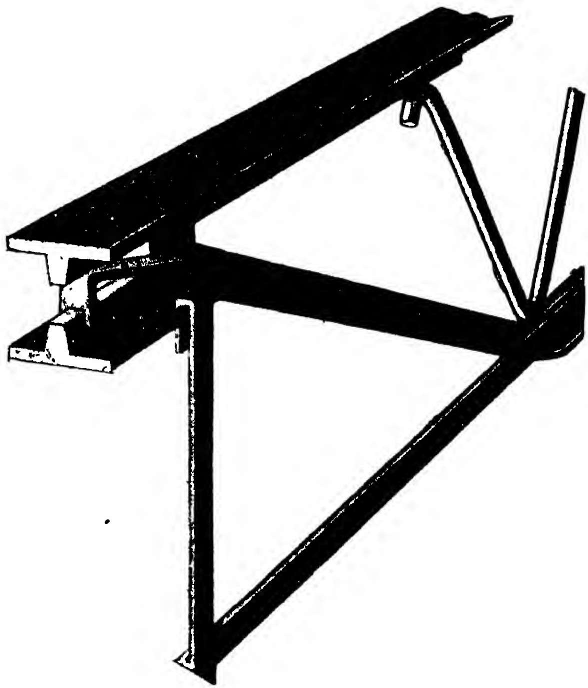


FIG. 5,690.—Typical ceiling extension used with open truss steel joists. When plastered ceilings are to be attached directly to the joists, ceiling extensions of the proper size must be provided at the ends of joists These ceiling extensions are readily applied after the joists have been completely installed, and also permits the installation of pipes of considerable lengths adjacent to the supporting wall or structural member without interference Two slots are provided in each end of each joist and the ceiling extension is slipped through the lower slot and hung in the upper one as illustrated

Decks or Top Slabs.— A concrete top slab 2 inches thick shall be used for floor and roof construction. The concrete top slab shall be reinforced and supported by 3/8 inch rib lath weighing 4.0 lbs. per square yard for joist spacings up to 24 inches and 3/4 inch rib lath weighing 0.60 lb. per square foot for joist spacings from 24 inches to 30 inches. The rib lath shall be placed over the joists with the ribs up and at right angles to the joists.

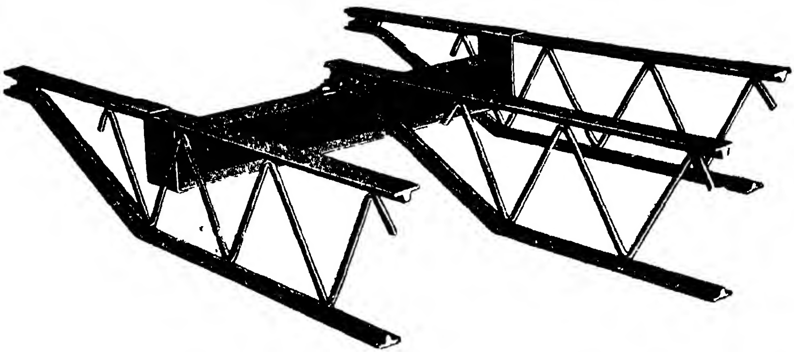


FIG. 5,691 — Illustrating the use of headers for framing around openings. Where small openings (not over 4 ft.) are required in steel joist roof construction, framing can be accomplished by means of special headers. The tail joist is bolted to the top of the header as shown. For openings greater than 4 ft. the framing should be accomplished by means of structural steel.

Top lath shall be attached to the top joists by means of lath clips spaced 8 inches apart. The ends of all the sheets shall be lapped at least 2 inches when the laps occur directly over the joists and 4 inches between joists. All laps shall be securely wired together.

Where the floor finish is other than wood, the structural slab shall be reinforced against temperature stresses with 6 x 6, 10 10 welded wire reinforcement placed near the top of the slab.

Precast concrete top slabs, precast gypsum top slabs, wood decks, or steel decks may be used over steel joists provided they are securely attached to the top chords to prevent any lateral deflection

Where small differences in levels between tops of adjacent joists occurs due to slight inaccuracies in manufacturing or to methods employed in their installation, provision must be made to insure a uniform and level bearing prior to placing the precast slabs over the steel joists. This may be done by placing shims or some type of plastic material over the top flange of each joist as required.

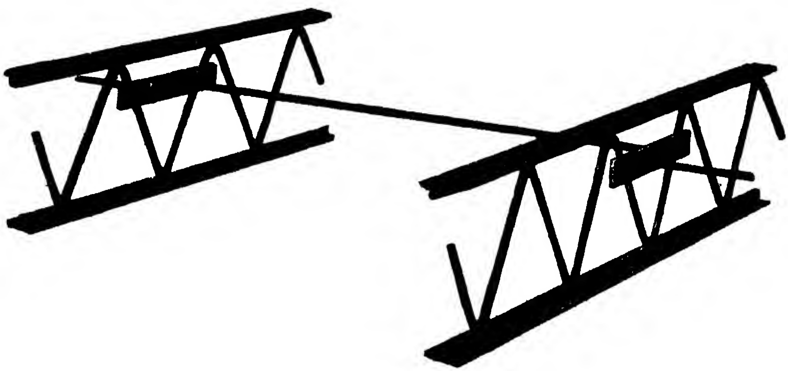


FIG. 5,692.—Showing method of sag rod connection in steel joists. When open truss steel joists are used as purlins on pitched roofs and are placed at right angles to the slope, sag rods are generally necessary, and these require sag rod plates attached to the joists. The plates are welded to the web members of the joists as illustrated

Steel Joist Institute Specifications

The provisions relating to structural requirements for steel joists are promulgated by the *Steel Joist Institute* and are as follows:

Section 100. Scope.—(**a**) These specifications cover the use of "Steel Joist Construction" in any structure to be erected under the provisions of these specifications.

Note: When these Standard Specifications for Steel Joists are used in a building code as Building Regulations for Steel Joist Construction, in all instances where the word "specifications" appears in these Standard Specifications, the word "regulations" is to be substituted therefor, and Section 100, Paragraph (a) as given above is to be replaced with the following:

"(*a*) These regulations cover the use of "Steel Joist Construction" in any structure to be erected under the provisions of this building code, of which they form a part. They are intended to supplement the general provisions of this building code in order to provide for the proper design and erection of structures of this type of construction. In all matters pertaining to the design and erection of "Steel Joist Construction: where these specific regulations may be in conflict with other provisions of the code, these regulations shall govern."

(*b*) "Steel Joist Construction" as governed by these specifications shall be that type of construction where decks or top slabs, as defined in Section 110 of these specifications, are supported by separate steel members herein referred to as "steel joists" spaced not further apart than twenty-four (24") inches on centers in floors and thirty (30") inches on centers in roofs, but in no case spaced farther apart than the safe span of the top slab, deck or flooring over said steel joists. Where such separate steel members are used at wider spacings than specified in this paragraph herein, the construction shall not be considered as "Steel Joist Construction" as defined in these specifications.

Section 101. Definition of Steel Joist.—Any steel member suitable for supporting floors and roofs between the main supporting girders, trusses, beams or walls when used as hereinafter specified shall be known as a "steel joist." Such steel joists may be made of hot or cold formed sections, strip, or sheet steel, riveted or welded together, or by expanding.

Section 102. Materials.—(*a*) All steel used shall conform to the American Society for Testing Materials Standard Specifications for Steel for Bridges and Buildings Designation A7 of latest adoption.

(*b*) All steel joists shall receive one coat of asphalt base paint applied by dipping or spraying, or an equivalent protective covering, before leaving the shop.

Section 103.— Connections.— (*a*) The joints and connections of all steel joists shall be made by connecting the members directly to one another by fusion or resistance welds or by rivets. In the case of expanded steel

STEEL JOIST INSTITUTE STANDARDS

Joist Type	Nominal Depth Inches	STEEL JOIST INSTITUTE STANDARDS				Average Weight per Foot of Joist Pounds
		Resisting Mom Inch Pounds	Resisting Mom Foot Pounds	Max End Reaction Pounds	Section Modulus Inches^3	
81	8	29500	2458	1600	1.64	3.12
82	8	52500	4375	1900	2.92	4.00
102	10	63000	5250	1900	3.50	4.00
103	10	82000	6833	1950	4.56	4.68
104	10	100000	8333	2200	5.56	5.65
123	12	92000	7667	2200	5.11	5.00
124	12	115000	9583	2300	6.39	5.65
125	12	142000	11833	2500	7.89	6.80
126	12	175000	14583	2700	9.72	8.00
145	14	156000	13000	2900	8.67	6.92
146	14	205000	17083	3100	11.39	8.00
147	14	246000	20500	3400	13.67	9.55
166	16	232000	19333	3200	12.89	8.30
167	16	281000	23417	3600	15.61	9.60

joists, a portion of the metal may be left intact to form a connection. All joints and connections shall be capable of withstanding a load at least three (3) times the designed load and shall be sufficiently rugged to resist the stresses incident to handling and erection when handled in a reasonable manner.

Members meeting at a joint shall have their lines of center of gravity meet at a point if practicable, if not, stresses arising from eccentricity shall be included with other stresses in designing the members. In no case shall the eccentricity of any intermediate joint exceed three-quarters (¾) of the least diameter of the largest member connected but end members may be designed as projecting beams. Ends of steel joists shall be designed to resist the bending produced by eccentricity of the reaction at the support.

(*b*) In the case of nailer steel joists, wood nailer strips shall be firmly attached to the top chords or top flanges of the steel joists. Such nailer strips shall be of a good grade of wood at least 1½"x1½" in net section. The attachments of the nailer strips shall, in conjunction with the top deck or slab, provide adequate lateral support to the top chords or top flanges of the steel joists.

Section 104. Methods of Design and Stresses.—(*a*) An open web steel joist built up of bars or other sections or one fabricated by expanding a rolled section shall be designed as a truss. The compression stress in pounds per square inch in the top chord or diagonals shall not exceed 15,000 nor

$$\frac{18\,000}{1+\dfrac{l^2}{18\,000\,r^2}}$$

when the length l of the member is the distance clear of welds or other attachments and r is the corresponding least radius of gyration of the member or any component part thereof.

The ratio of l to r shall not exceed 1[illegible]0. In the completed structure the top chords of open web steel joists may be considered as being stayed laterally at panel points when the deck or top slab over the steel joists complies with the provisions of Section 110 of these specifications.

The minimum shear to be used in designing the web members at any point in an open web steel joist shall be not less than fifty ([illegible]0) percent of the required maximum end reaction for such steel joist. In computing the resistance of open [illegible] steel joists to loads incident to construction as described in Section 104(c) of these specifications.

The top chords shall satisfy the additional requirements that they shall safely carry the resulting compression using l as the distance between lines of bridging and r as the least radius of gyration of the top chord of any one steel joist around a vertical axis but the ratio of l to r in this case shall not exceed [illegible]00; however, the permissible stresses in pounds per square inch as established elsewhere in this Section 104(a) may be increased by one third. In no case shall the lines of bridging be spaced further apart than that permitted in Section 108(b).

No bending stresses shall be assumed in top chords of open web steel joists supporting poured concrete slabs which have a thickness of more than one fourteenth (1/[illegible]) of the distance between supports under the top chords, but for open web steel joists supporting concrete slabs thinner than this the theoretical bending stress for a uniform load shall be computed and subtracted from the allowable stress.

In the design of open web nailer steel joists the nailer strips shall not be assumed to carry any part of the stresses in the steel joists, but if adequate may be assumed to carry the supported load to the panel points. When bending stresses in top chords of open web steel joists must be considered the combined axial compression and bending stress at the center of the panel shall not exceed the permissible compression stress set forth above in this paragraph, and at points of vertical support of the top chords shall not ex

ceed eighteen thousand (18,000) pounds per square inch. The tensile stress shall not exceed eighteen thousand (18,000) pounds per square inch in any member

(*b*) A solid web steel joist shall be designed as a beam The maximum fiber stress in tension shall not exceed eighteen thousand (18 000) pounds per square inch The maximum fiber stress in compression shall not exceed eighteen thousand (18 000) pounds per square inch nor

$$\frac{20\,000}{1+\frac{l}{2\,000\,b}}$$

when the length l is the distance between lateral supports of the compression flange and b is the width of the compression flange

The greatest average shear in pounds per square inch on the gross area of the web shall not exceed

$$12\,000 \text{ nor } \frac{18\,000}{1+\frac{h}{7\,200\,t}}$$

when h is the clear distance between flanges and t is the thickness of the web When the web of a solid web steel joist is made of two or more sheets of metal each sheet shall be considered as a separate member each sheet carrying its share of the shear

In the completed structure the top flanges of solid web steel joists may be considered as being stayed laterally when the deck or top slab over the steel joists complies with the provisions of Section 110 of these specifications

In computing the resistance of solid web steel joists to loads incident to construction as described in Section 107(c) of these specifications the top flanges shall satisfy the additional requirements that they shall safely carry the resulting compression using l as the distance between lines of bridging and b as the width of the compression flange but the ratio of l to b shall not exceed 40 however the permissible stresses in pounds per square inch as established elsewhere in this Section 101(b) may be increased by one third In no case shall the lines of bridging be spaced farther apart than that permitted in Section 108(b) In the design of solid web nailer steel joists the nailer strips shall not be assumed to carry any part of the stresses in the steel joists

(*c*) When a wood sleeper (nailing screed) is embedded in a top slab of poured concrete not less than two (2") inches thick and as specified in Section 104(a) bending stresses in the top chord of an open web steel

joist need not be considered, provided the wood sleeper (nailing screed) is elevated a minimum of one (1″) inch above the top chord of the steel joist. In the case of an open web nailer steel joist, bending stresses in the top chord need not be considered, provided a wood nailer strip adequate to carry the supported load to the panel points is attached to the top chord in accordance with the provisions of Section 103(b) of these specifications. When precast interlocking top slabs are used over open web steel joists and are of sufficient width and rigidity to transmit a uniform floor or roof load to the panel points without the assistance of the top chords between panel points, bending stresses in the top chords need not be considered.

Section 105. Span. (*a*) The span of steel joists shall not exceed twenty-four (24) times the depth of the steel portion of the steel joist.

(*b*) The span of open web steel joists shall not exceed five hundred fifty (550) times the least radius of gyration of the top chord around a vertical axis, but in case the top chord consists of a flat top section continuous with a center web, the radius of gyration of the top plate alone shall be taken.

Section 106. Spacing. The spacing of steel joists in "Steel Joist Construction" shall be in compliance with the provisions of Section 100(b) herein. In other than "Steel Joist Construction" steel joists may be used, in accordance with the provisions of Section 113 of these specifications, at spacings greater than that permitted by Section 100(b) herein, to support wood or steel roof decks.

Section 107. Erection. (*a*) The ends of steel joists shall extend a distance of at least four (4″) inches onto masonry or reinforced concrete supports and at least two and one-half (2½″) inches on steel supports. Every third steel joist on concrete or masonry supports shall be anchored thereto with an anchor equivalent to a three-eighths (⅜″) inch round.

The ends of all steel joists supported on masonry walls shall be bedded in mortar. All steel joists supported on steel beams shall be secured thereto with an anchor made of not less than a three sixteenths (3/16″) inch bar fastened over the flanges of the supporting beams, except in the case of buildings having a height of more than twice the least dimension of the base, in which case each steel joist shall be welded to the supporting steel work with two (2) welds at each end, each one (1″) inch long, or by means of a one-half (½″) inch bolt or rivet at each end. In the case of buildings having a height of more than two and one-half times the width of the base, the structural frame and floors must be depended upon to distribute the wind load horizontally.

In general, welded or bolted attachment of steel joists to supporting beams as well as thicker top slabs than used in buildings of lesser heights

may be advisable. At all supports where the steel joists are anchored with a hook anchor only, and in buildings having a height of more than ([illegible]) times the width, the top lath or other centering shall be cut and formed to permit concrete of top slab to fill space around the ends of the steel joists.

(*b*) All steel joists shall be fastened in place and permanent bridging installed before any construction loads (except the weight of the necessary workmen to install the bridging) are placed upon the steel joists.

(*c*) During the construction period, care shall be exercised to prevent excessive concentrated or moving loads. The construction contractor shall provide for adequate distribution of such loads so that the carrying capacity of any steel joist is not exceeded during that period. When erected and bridged the total concentrated load on any one steel joist shall not exceed eight hundred (800) pounds, and in the case of open web steel joists, such concentrated load shall not be imposed between panel points.

Section 108. Bridging. (*a*) As soon as steel joists have been erected, bridging shall be installed between them before the application of construction loads. This bridging shall be adequate to safely support the top chords or flanges against lateral movement during the construction period and shall hold the steel joists in an approximately vertical plane passing through the bearings.

The steel joists at the ends of panels shall be braced laterally by anchors or ties at each line of bridging. If diagonal bridging be used in which all diagonal members will resist only tension, they shall not be less than a three-sixteenths ([illegible]) inch round rod, and these diagonals shall be supplemented by a continuous strut adequately attached to the top chords or flanges of all steel joists so bridged. This top strut shall be equivalent as a strut to one-half ([illegible]) inch round steel bar. If diagonal members be used which are capable of resisting both tension and compression, the top strut may be omitted.

In case bridging in the form of horizontally placed beams or angle sections is provided, it must be so connected to the steel joists that it will support the top chords or flanges against lateral movement and hold the steel joists approximately in a vertical plane. Fourteen (14) gauge wire diagonals shall be used to secure the bottom chords or flanges at each line of bridging of this type. Wire may be omitted when bridging which restrains both top and bottom chords or flanges is used. When the spacing of steel joists exceeds thirty (30) inches on centers in roofs, sag rods may be used in lieu of any of the above types of bridging.

(*b*) The number of lines of bridging provided shall be not less than that specified in the following table.

Span	*Number of Lines of Bridging.*
Up to 14 feet	one row, near center
14 to 21 feet	two rows approximately 1/3 span apart
21 to 32 feet	three rows

(*c*) In the case of nailer steel joists carrying a wood deck, the wood deck may be used as the top member of the bridging system.

Section 109. Use of Steel Joist Construction. (*a*) When used in any structure where wood joists are permitted, steel joists may have a wood nailing strip attached to the top chord or flange and a wood floor may be used over such steel joists.

(*b*) Wherever construction having a one-hour fire resistance are required or permitted, Steel Joist Construction may be used as follows:

One Hour Fire Resistance. Steel Joist Construction with 2 inch thick top slab of cast in-place or precast metal-reinforced Portland cement or gypsum concrete with ceiling protection of not less than three-quarter (3/4") inch thick gypsum or Portland cement plaster on metal or paper-backed metal lath, the thickness of plaster being measured from the back of the lath. Gypsum plaster is to be not leaner than 1:2 by weight of cementing materials and dry sand for the scratch coat and not leaner than 1:3 for the brown coat.

Portland cement plaster is to be not leaner than 1:3 by volume of cementing materials and dry sand. In such Portland cement plaster, hydrated lime may be added in an amount not to exceed 10% of the Portland cement by weight. Wood or metal nailing strips or screeds for attachment of wood flooring shall have not less than 1 in. of concrete between them and the top of the steel joists. They may be supported on metal chairs attached to the steel joists. Precast slabs must have joints grouted and be finished over with a coating of mortar or otherwise designed and constructed to assure tight end and side joints.

(*c*) Wherever construction having a one and one-half hour fire resistance are required or permitted, Steel Joist Construction may be used as follows:

One and One-Half-Hour Fire Resistance. Steel Joist Construction with 2 in. thick top slab of cast in-place or precast metal reinforced Portland cement or gypsum concrete with ceiling protection of not less than three-quarter (3/4") inch thick gypsum or Portland cement plaster on metal or paper-backed metal lath, the thickness of plaster being measured from the back of the lath. Gypsum plaster is to be not leaner than 1:2 by weight of cementing materials and dry sand for the scratch coat and not leaner than 1:3 for the brown coat.

Portland cement plaster is to be not leaner than 1:3 by volume of cementing materials and dry sand. In such Portland cement plaster, hydrated lime may be added in an amount not to exceed 10% of the Portland cement by weight and short fibered (refiberized) asbestos shall be added in an amount from 2% to 3% of the Portland cement by weight. Wood or metal nailing strips or screeds for attachment of wood flooring shall have not less than 1 in. of concrete between them and top of the steel joists. They may be supported on metal chairs attached to the steel joists. Precast slabs must have joints grouted and be finished over with a coating of mortar or otherwise designed and constructed to assure tight end and side joints.

(*d*) Wherever construction having a two-hour fire resistance are required or permitted, Steel Joist Construction may be used as follows:

Two-Hour Fire Resistance: Steel Joist Construction with top slab of cast-in-place metal reinforced Portland cement or gypsum concrete not less than 2 in. thick over the top of the joists, or with a 2 in. thick top slab of precast metal-reinforced gypsum concrete with ceiling protection of gypsum plaster on metal or paper backed metal lath, plaster not leaner than 1:2 by weight of plaster and dry sand for the scratch coat and 1:3 for the brown coat, thickness to be not less than three-quarter ($\frac{3}{4}''$) inch as measured from the back of the lath.

Any wood or metal nailing strips must be underlaid with concrete carefully packed under them to a thickness not less than $1\frac{1}{4}$ in. over the top of the steel joists Precast slabs must have joints grouted and be finished over with a coating of mortar. In lieu of grouted joints, they must be designed and constructed to assure tight end and side joints.

(*e*) Wherever constructions having a three-hour fire resistance are required or permitted, Steel Joist Construction may be used as follows:

Three-Hour Fire Resistance.- Steel Joist Construction with top slab of cast-in-place metal reinforced Portland cement or gypsum concrete not less than $2\frac{1}{2}$ in. thick over the top of the joists with ceiling protection of gypsum plaster on metal or paper-backed metal lath. Plaster is to be not not less than one (1″) thick if neat gypsum plaster be used to which may be added sisal fiber, wood fiber, or asbestos fiber to increase workability.

Plaster is to be not less than three-quarter ($\frac{3}{4}''$) inch thick if neat gypsum plaster and the expanded vermiculite proportioned in the range 2.1 to 3:1 gypsum to heat-expanded vermiculite by weight be used. In each case the thickness of plaster is measured from the back of the lath. Any wood or metal nailing strips must be underlaid with concrete carefully packed under them and not less than $1\frac{5}{8}$ in. thick above the top of steel joists.

(*f*) Wherever construction having a four-hour fire resistance are required or permitted, Steel Joist Construction as described in either of the two subsequent sub-paragraphs of this Paragraph (f) may be used as follows:

Four-Hour Fire Resistance.—Steel Joist Construction with top slab of cast-in-place metal-reinforced Portland cement or gypsum concrete not less than 2½ in. thick over the top of the joists with ceiling protection of not less than one (1″) inch thick gypsum-vermiculite plaster applied on metal lath and proportioned in the range 2:1 to 3:1 gypsum to heat-expanded vermiculite by weight, the thickness of plaster being measured from the back of the lath. There must be no wood or metal connection between the top of the steel joists and any wood or metal nailing strips, these latter to be underlaid with not less than 1⅝ in. of concrete over the top of the steel joists.

Four-Hour Fire Resistance (Alternate Construction).—Steel Joist Construction with 2 in. thick top slab of cast-in-place or precast metal reinforced Portland cement or gypsum concrete with ceiling protection of metal-reinforced gypsum slabs 2 in. thick covered with not less than ½ in. of 1:2 sanded gypsum plaster.

Wood or metal nailing strips or screeds for attachment of wood flooring shall have not less than 1½ inch of concrete between them and the top of the steel joists. They may be supported on metal chairs attached to the steel joists. Precast slabs must have joints grouted and be finished over with a coat of mortar or otherwise designed and constructed to assure tight end and side joints. In lieu of grouted joints they must be designed and constructed to assure tight end and side joints.

(*g*) Steel joists may be used in all buildings of human occupancy. Steel joists may be used in buildings of store, manufacturing, storage or warehouse occupancy; but where such buildings are subjected to unusual concentrated or moving loads, the required live load shall be not to exceed 125 pounds per square foot and the top slab shall be designed to adequately support and distribute such loads and adequate lateral support shall be provided to steel joists to support them against lateral loads.

Section 110. Decks and Top Slabs. -(*a*) Decks or top slabs over steel joists may be of concrete or gypsum poured on metal lath centering attached to the top chords or flanges of steel joists as required elsewhere in this section or on removable centering provided the top chords or flanges of the steel joists are properly stayed by the concrete or gypsum slab.

Other equally suitable permanent centering may be used, provided it is substantially attached to the top chords or flanges as required elsewhere in this section and provided these attachments (or the centering itself) are securely anchored into the concrete or gypsum slab. Precast concrete or

precast gypsum slabs when securely attached to the top chords or flanges and anchored thereto and brought to a firm bearing, wood decks as specified in these specifications, and corrugated or other steel roof decks securely anchored to the top chords or flanges may be used over steel joists.

Any attachment or pair of attachments when applied shall be capable of staying the top chord or flanged laterally in both directions and in the case of open web steel joists, shall be spaced not farther apart than the panel point spacing. Decks or top slabs over steel joists shall not be assumed to carry any part of the compression stress in the steel joist.

(*b*) Flat wood decks of single thickness of seven-eights (7/8") inch material shall not have a span of more than twenty (20") inches for floors or thirty (30") inches for roofs. All such decks shall be securely fastened to the wood nailer strips.

(*c*) Poured structural slabs of concrete, gypsum or other similar material shall not be less than two (2") inches thick. They shall be poured upon three-eighths (3/8") inch ribbed metal lath weighing not less than four (4) pounds per square yard for spans not exceeding 24 inches and upon three-quarter (3/4") inch rib lath weighing not less than .50 pounds per square foot for spans not exceeding 30 inches.

Other material equally suitable as a form or centering for casting concrete or gypsum slabs may be used in place of rib lath. Rib lath or other centering which remains in place shall be substantially attached to the top chord or flange of each steel joist at intervals of not over eight (8") inches. Such slabs shall be reinforced with mesh or rods, in addition to their rib lath, except that when slabs are to be covered with a wood strip top floor, the rib lath or centering may, if adequate, serve also as the reinforcement.

(*d*) Any material used as centering for the top slab shall be installed so as not to exert an undue lateral pull on the top chords or flanges of the steel joists.

Section 111. Deflection.—The deflection of the finished floor due to the designed live load shall not exceed one three hundred sixtieth (1/360) of the span. The permanent deflection resulting from loading a finished floor to twice the designed live load for twelve (12) hours shall not exceed twenty (20%) percent of the total deflection for this load.

Section 112. Factor of Safety.—The maximum total uniform load at failure of a steel joist floor shall not be less than two (2) times the total designed load of steel joists as computed by using the stresses permitted herein. Steel Joist Construction, if required to be tested, shall have bridging and top deck applied as ordinarily used and the test load shall be uniformly distributed.

Section 113. Wood and Steel Roof Decks.—Where wood or steel decks are used for roof construction, steel joists may be used at spacings in excess of the limitations prescribed in Section 100(b) of these specifications. However, where such wider spacings are used, the construction shall not be considered as "Steel Joist Construction" as defined in these specifications but shall be designed and constructed in accordance with recognized engineering practice to safely support all loads without exceeding the unit stresses specified in these specifications herein.

Uses of Structural Shapes.—Each of the shapes has certain uses to which it is especially adapted. Briefly the uses are given below.

I Beams.—Used principally as beams and girders to carry floors, roofs and walls; also to some extent as columns when the loads are relatively light.

Channels. Used extensively in pairs, latticed, and in combination with other shapes for columns. They are rarely used singly as columns. Sometimes they are used in pairs, latticed or with plates across flanges for the chords in trusses.

Angles. Used most extensively in combination with other shapes to form columns, for members in trusses, and for the flanges of riveted girders.

They are rarely used singly as columns except for light loads As beams they are used only for very light loads such as short lentels, ceiling and roof purlins, when close spacing is necessary They are used especially for the connection of beams and columns and of other members one with another, and for any position requiring a shelf for the support of other work.

T Bars. Used principally as beams of short span and close spacing, where the loads are light and where a flange on each side of the center rib is necessary, as in short lintels, ceilings, skylights, etc. Rarely used in the construction of riveted members.

Z Bars. - Used mostly in columns, four being connected by a webb plate or lattice bars. Usually angles or T's can be used to equal advantage with less expense.

Plates.—Used especially as connecting members in nearly all riveted work, but rarely alone except as bearing surfaces on masonry and in some cases as built in shelves and as projections for masonry to serve as bearing plates.

Troughs.—Used for bridge work for floors.

Rods and Bars.—Used especially as tension members in trusses.

Erection of Steel Buildings.—The rigging and the scaffolding necessary for the erection are, perhaps, the most important

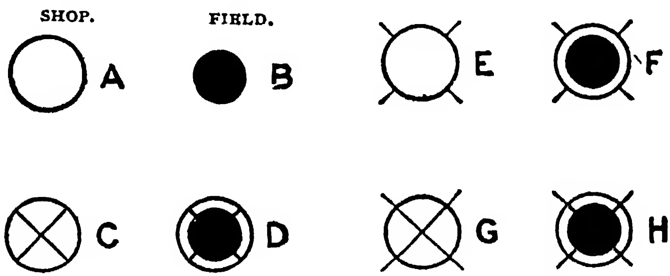
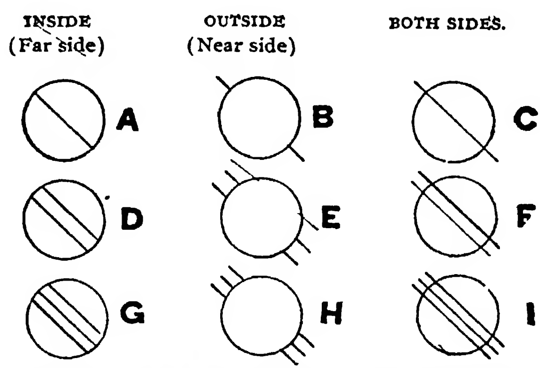


Fig. 304.

FIGS. 5,722 to 5,729.—Symbols for riveting: **1.** **A** and **B**, two full heads; **C** and **D**, countersunk inside (far side) and chipped; **E** and **F**, countersunk outside (near side) and chipped; **G** and **H**, countersunk and chipped both sides.



FIGS. 5,730 to 5,738.—Symbols for riveting: **2.** **A** to **C**, flattened to ⅛ in. high, or countersunk and not chipped; **D** to **F**, flattened to ¼ in. high; **G** to **I**, flattened to ⅜ in. high.

considerations, and will be dealt with under their respective heads. Whatever of riveting requires to be executed is

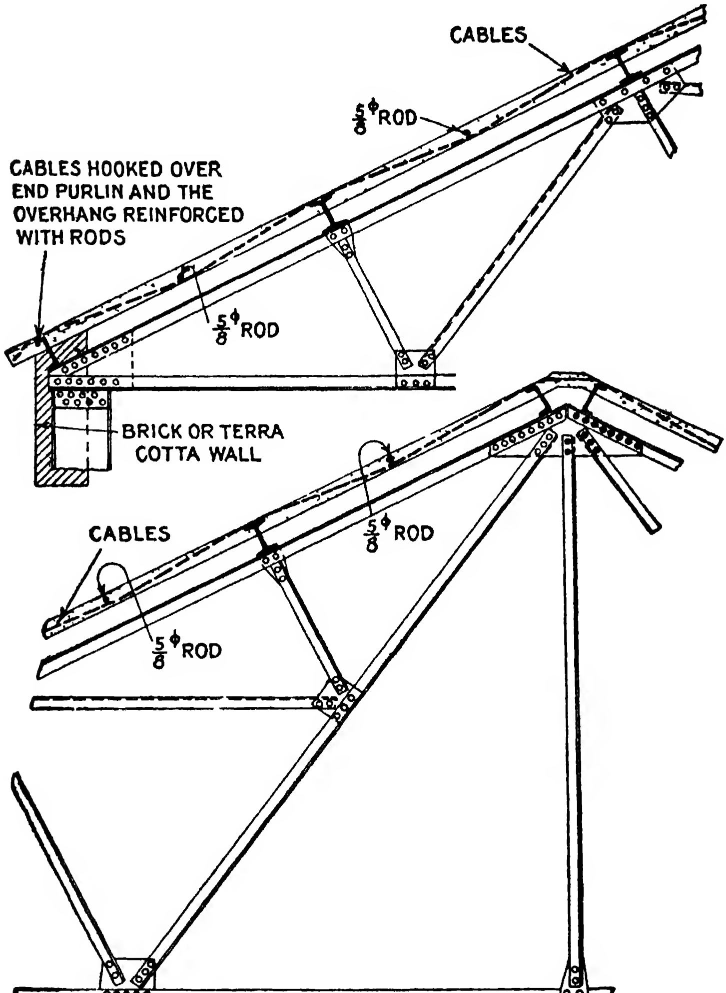


FIG 5,739.—Standard hip truss, fire proof roof construction, lower end.

FIG 5,740 —Standard hip truss, fire proof roof construction, upper end

effected either at the manufactory or on the ground. The connecting up of the various members being done with bolts, the tools used are few and simple.

Two points must be impressed upon the erector. *First*, to study the plans and blue-prints carefully and often; to keep them arranged for easy reference, the particular drawing in use being pinned out on a board at a convenient spot.

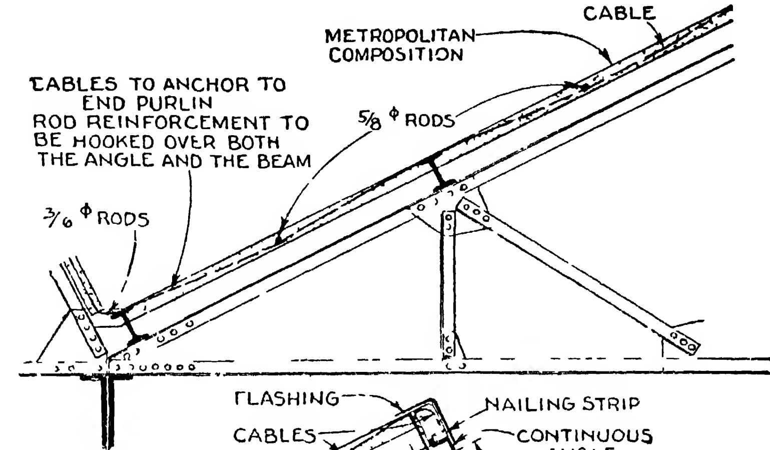
Second, to watch the *erection marks* and *numbering* of the various parts with care, in order that the proper part may be fitted into the place destined for it.

The usual method followed for *erection marks* is to designate each similar division of the structure with one of the letters of the alphabet.

Thus each roof truss of a building, together with its supporting pillars, will be lettered A, B or C, etc.; these letters showing on the blue print, and also stencilled on the iron work. The individual details of each member will be further figured 1, 2, 3 or 4 on the blue print and on the member. Thus, if the king post of the roof truss be marked 7, on the drawing, and a piece of iron is found bearing the mark C7, it will at once be identified as the king post of the third truss.

Longitudinal members are marked with a number according to their position, and with letters to show between what sections they have to go. An angle bar is discovered with the mark B10C, and is at once seen to be purlin No. 10 to go between trusses B and C, the letters toward that particular truss.

Many parts of a structure are made to template, and thus are interchangeable, but it is as well always to spend a little time in seeing that the right parts go together, as the drilling of girders, etc., is not usually so careful as that practiced in up-to-date boiler shops, despite spacing drills, multiple punches and the like. It is, also, frequently to be noticed that where two or three plates come together, the corners have been tapered down subsequent to the drilling or punching of the holes, and "half-moons" are of frequent occurrence.



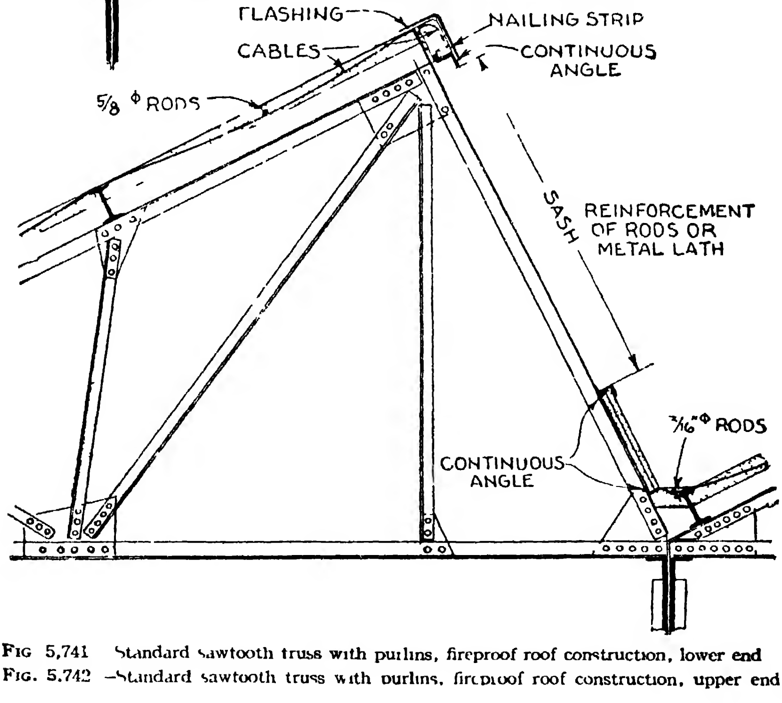


FIG 5,741 Standard sawtooth truss with purlins, fireproof roof construction, lower end
FIG. 5,742 —Standard sawtooth truss with purlins, fireproof roof construction, upper end.

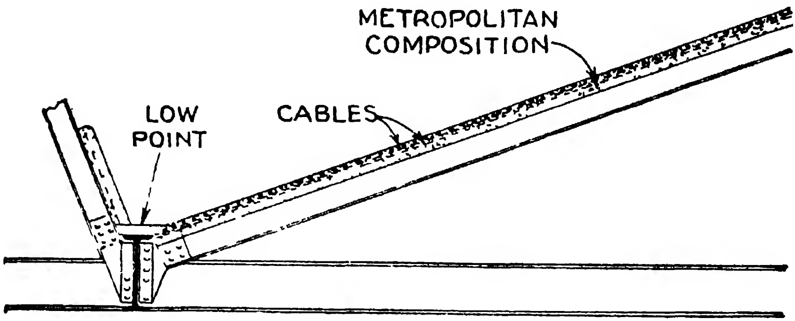


FIG. 5,743.—Standard sawtooth without purlins, fireproof roof construction, lower end.

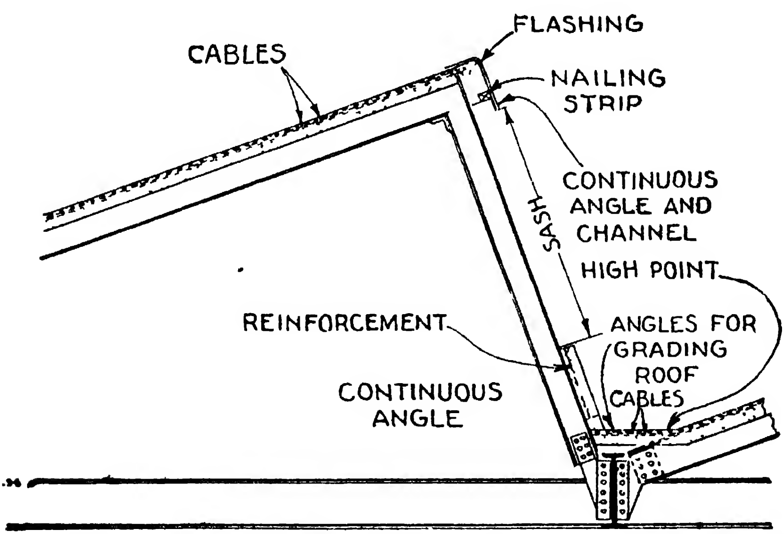


FIG. 5,744. —Standard sawtooth without purlins, fireproof roof construction, upper end.

This rough style of work requires careful manipulation, and fairing of the holes, and reaming followed by the use of a larger rivet is often to be recommended.

Care should be exercised in slinging any girder, so that its ends come in the proper direction; the channel irons should also be observed to see that they face the right way. Brackets and knee pieces should be examined for marks, and, if their location be doubtful, should be tried on to their connecting pieces to see that the holes are fair. It is frequently necessary to do some drilling with these last.

In bolting up connecting pieces, the boiler maker's spanner or fork wrench, is most useful; the pointed tail or stalk is used as a "podger" to make the first connection as the new part is slung into place, and a little maneuvering fairs the holes so that one or two bolts can be entered.

In this connection, stress must be laid upon two points in dealing with bolting up structures: 1, Never put a finger into a bolt hole to feel if the two pieces be fair; many a man has lost his finger by so doing when the girders have swung a little. 2, Do not tighten a single bolt in a joint until *all* are in, as occasional working of the parts is necessary to enter some of the bolts.

Bolts should be long enough to give a full nut, in fact it is advisable that they protrude two threads through the nut.

All nuts should be gone around two or three times to be certain that they are tight, and wherever much shaking of the ironwork is to be apprehended, the bolt ends should be clenched over.

In riveting, an abundance of service (temporary) bolts should be put in, so that the different pieces of iron are drawn tightly together and the holes held fair.

A certain amount of drifting, or at least, maneuvering with "podgers" and spanner ends must be expected, and all holes should be fair before starting to rivet, as the practice of drifting after some rivets have been set is detrimental to the holding power of those rivets not yet cooled.

The rivets should be well bucked or hammered to fill the holes before proceeding to form the point, as, if the hole be not well plugged, the rivet will not stand its calculated strain.

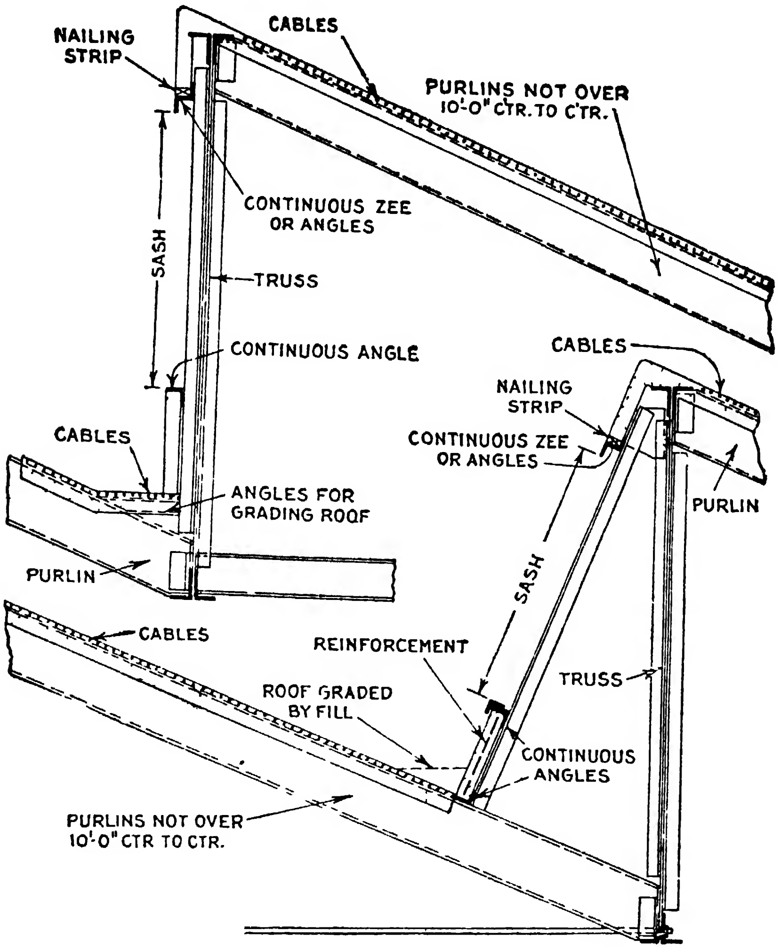
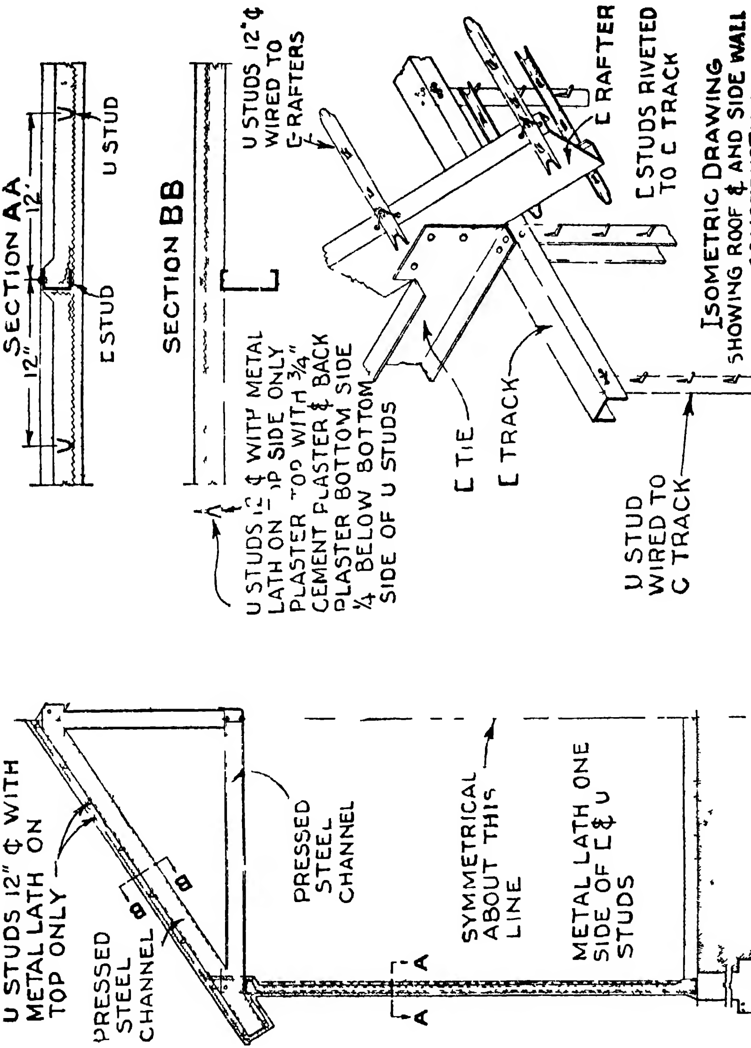


FIG 5,745 —Standard sawtooth with vertical or inclined face; fireproof roof construction, upper end

FIG. 5,746 —Standard sawtooth with vertical or inclined face, fireproof roof construction, lower end.



FIGS. 5,747 to 5,750.—Details of pressed steel frame construction showing various sections and detail of roof

Snap, otherwise known as cup or hemispherical, heads and points are the best for this class of work, as the hole is well filled with smashing the rivet down, and a few blows of the flogging hammer on the set form a shapely point with good holding power, and serve to draw the plates well together.

CHAPTER 101

Building Suggestions and Hints

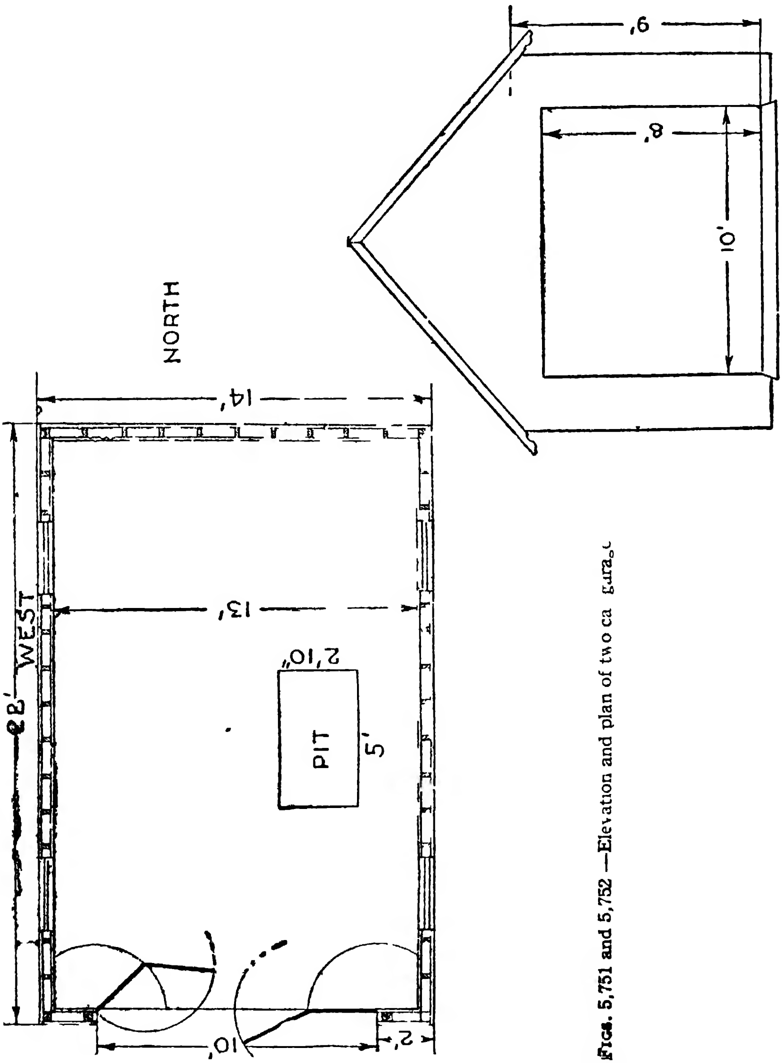
For home, farm, public buildings, and miscellaneous small jobs, concrete is very extensively used. Moreover, concrete is low in first cost, sanitary, an effective barrier against rats and vermin, attractive in appearance, and has a low rate of depreciation.

Among the miscellaneous uses to which concrete may be put the following list is suggestive of the many building improvements for which concrete is particularly suited:

The following building suggestions will prove helpful:

Basement floors	Flower boxes	Porch piers
Benches	Foundations	Septic tanks
Cisterns	Garages	Steps
Clothes line posts	Gate posts	Tree surgery
Cold frames	Hotbeds	Walks
Driveways	Laundry tubs	Well curbs and covers
Fence posts	Porches	Weights

Garage.—The design of a garage is generally influenced by the architectural treatment of the house and other buildings in the immediate neighborhood. A garage may be attractive and well constructed, but if the architectural treatment do not harmonize with that of adjacent buildings, the general effect is displeasing. Even where a house is old fashioned, it



Figs. 5,751 and 5,752 —Elevation and plan of two car garage

is well to let some feature of its design predominate in the new garage. However, the style of the garage is a matter that may safely be left to the discretion of the architect.

In building a garage don t make the mistake of building a one car building, have it at least large enough for two cars or if the outlay be too great let the design be such that a second car extension may be added at some future time when needed Figs 5,751 and 5,752 show the usual type of two car garage

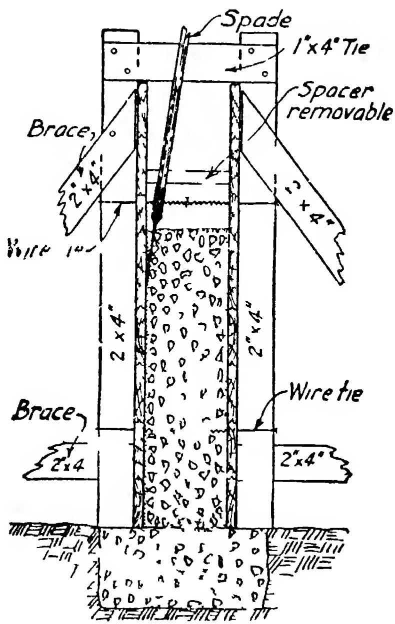


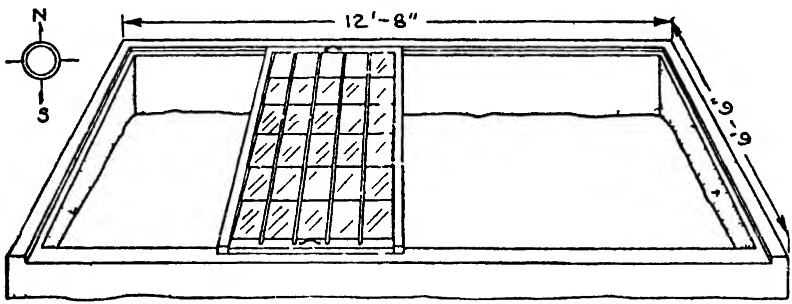
FIG 5,753 —Spading of concrete in wall forms This forces the coarse aggregate back from the face and produces a smooth surface on the finished wall

Hot Beds.—When built of concrete, hot beds and cold frames are rot proof and permanent The walls, 6 ins thick, project above the ground, 20 ins. on the north side and 8 ins. on the south side, and are carried to a depth of 3 ft. Well rotted

manure is placed in the bottom of the excavated interior 2 ft deep and covered with an 8-in. top of rich soil.

Usually cement hot beds require only the simplest of form construction, and where the ground is self sustaining only an inside form will be required for the cement work below ground level At ground level, both inside and outside forms must be provided for the walls above ground

For hot bed construction a 1 2½ 4 concrete will be suitable Walls should be from 6 to 8 ins thick with two ⅜ in round rods bent to a right angle at each corner these rods being 4 ft long and extending 2 ft into end and side walls When finishing the back wall (which is the higher one)



FIGS 5 754 and 5 755 —Concrete hot bed and direction indication for locating the higher wall

to provide for slope of sash it is very easy to embed fastenings in the concrete for attaching sash hinges

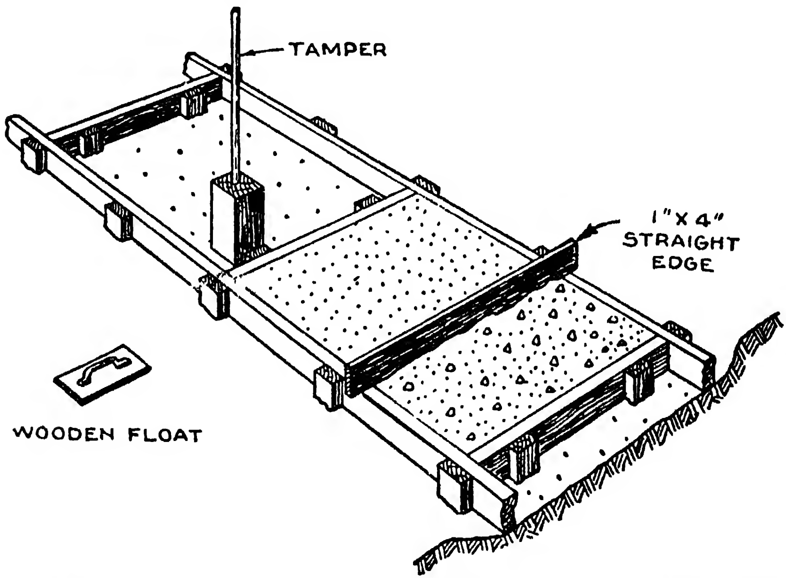
A very convenient adjunct of the cement hot bed is a 2 or 3 ft cement walk on the low side so as to make it easy to get around the bed during periods when the ground is wet This feature considerably increases the ease and comfort of working in and around the bed

No stretch of cement hot bed wall should be longer than 25 ft unless reinforced or unless the next section is completely divided from it by a contraction joint, as the expansion and contraction due to temperature changes in a stretch of hotbed wall longer than 25 ft is quite likely to result ultimately in cracks in the wall

Concrete Walks.—The concrete should always rest on a good firm base. If the soil on which the walk be laid be well

drained, the concrete can be placed directly on it after all loam, refuse, grass, roots and other perishable material have been removed and the area has been well compacted. If the soil be not well drained, a sub-base should be provided of well compacted, clean, coarse gravel or clean cinders.

Usually 2×4s, securely staked in position are used as side forms for

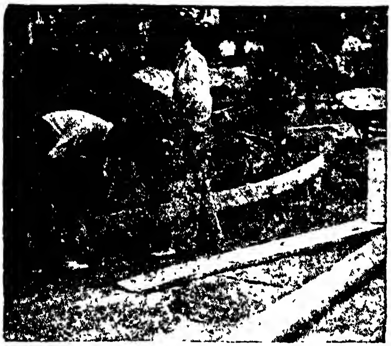


FIGS. 5,756 and 5,757.—Form for laying walk and wooden float. Fig. 5,756 shows ordinary tamper made of a square timber for compacting the soil, a straight edge and method of "striking off" surplus material preparatory to finishing with wooden float.

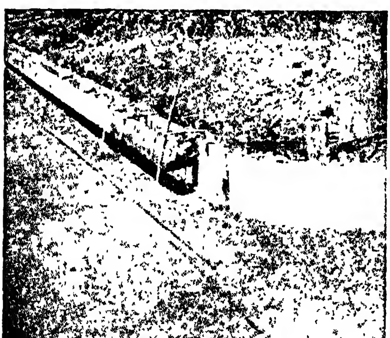
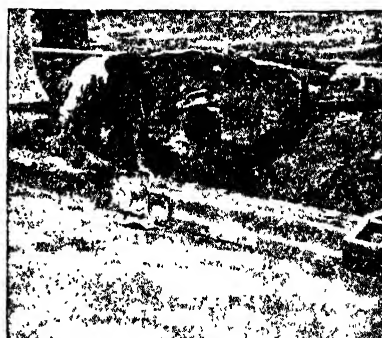
walk construction. Pavements are laid either as one course construction or as two course construction.

One course construction means that the full thickness of the walk or pavement is placed at one time, using one standard concrete mixture throughout. In two course construction the pavement is laid in two courses, using a certain mixture for the base and another (usually a mortar) for the top or wearing surface. One course construction is generally more satisfactory.

Concrete walks (and floors) should be blocked off with partition strip. and concrete placed for alternate slabs. After these have hardened enough to be self-sustaining the cross strips can be removed and the intermediate slabs concreted. The concrete already in place serves as a form for the intermediate slabs.




Figs. 5,758 and 5,759.—Integral curb construction 1. Fig. 5,758. Setting curb forms on returns; fig. 5,759, building up integral curb on returns.

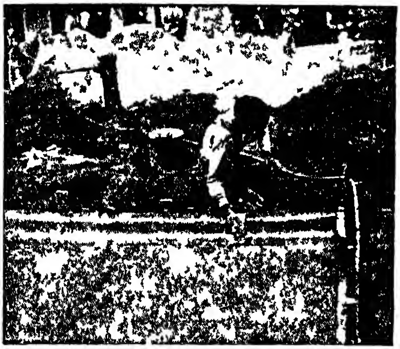



Figs. 5,760 and 5,761 —Integral curb construction 2. Fig. 5,760 A simple form for integral curb; fig. 5,761, facing the curb after forms are removed.

Thickness of walks may vary from 4 to 6 ins. according to the service which they must render. If a pavement is to be used only as a walk, 4 ins. is generally thick enough; but if wagons be likely to drive over it, 6 ins. should be the minimum thickness.

A 1:2:3 mixture is recommended. In mixing add enough water to produce

a concrete of pasty or jelly like consistency so that it can be spread out in the forms and easily leveled with a strike board resting on the edge of the forms. This strike board should be passed across the forms with a saw-like motion, thus leveling the concrete and filling the hollows, and at the same time assisting to compact it




FIGS 5,762 and 5,763.—Integral curb construction 3. Fig 5,762, finishing with specially shaped trowel; fig 5,763 giving final finish with brush

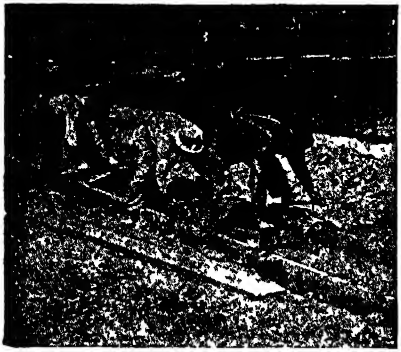

FIGS 5,764 and 5,765.—Combined curb and gutter construction 1. Fig 5,764, placing concrete in forms; fig 5,765 tamping concrete to approximate contour

The walk should be finished with a wood float to produce an even gritty surface. After the concrete has commenced to harden a cover of moist sand or earth about two inches thick should be thrown on and kept moist for ten days or so. At the end of this time the covering may be removed and the walk or floor put into use

Steps.—Concrete steps are easy to build and may be economically used in many ways.

There are two types of steps:

1. Those which rest on the earth, that is, are built on a slope.




FIGS 5,766 and 5,767 —Combined curb and gutter construction 2. Fig 5,766, striking off base course and mortar facing, fig. 5,767, finishing with curb machine


FIGS 5,768 and 5,769 —Combined curb and gutter construction 3. Fig. 5,768, edging—note division plates, fig 5,769, finishing with brush

2. Those which extend from one floor to another, or from the floor to the ground, and are supported at each end like a slab, so that they require reinforcement.

Before laying the first type, the slope on which they are to

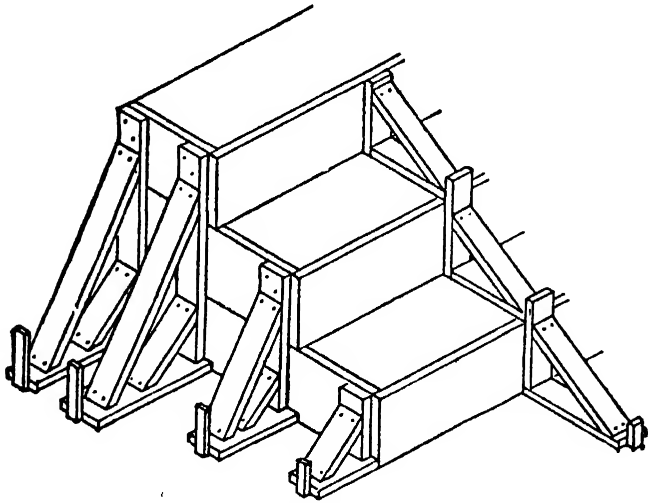


FIG. 5,770.—Forms for concrete steps showing proper method of bracing.

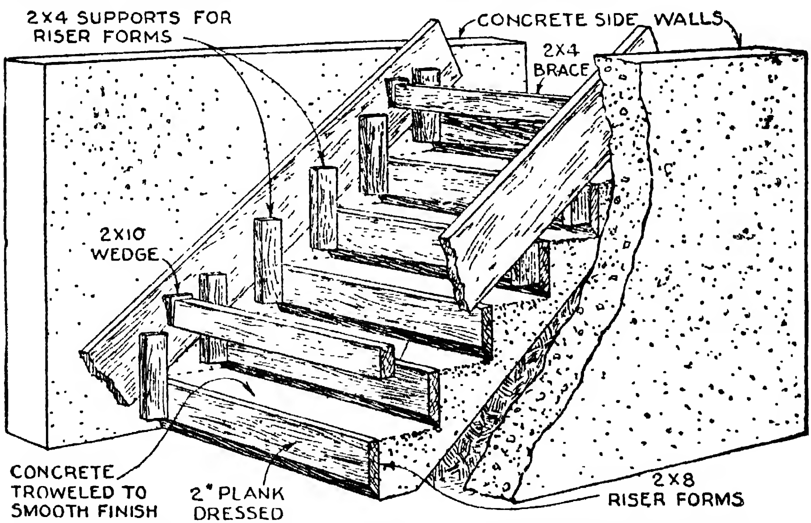


FIG. 5,771.—Forms for steps with concrete side walls, step slab resting on the ground.

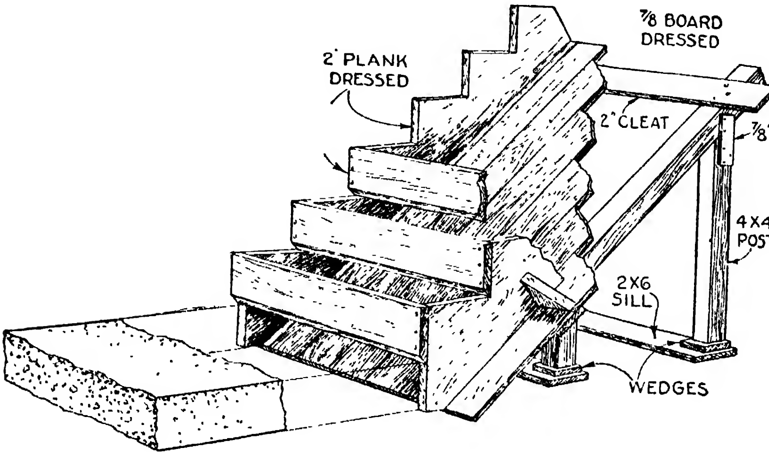


FIG. 5,772.—Forms for self-supporting concrete steps. In this type the slab is reinforced as shown in fig. 5,773.

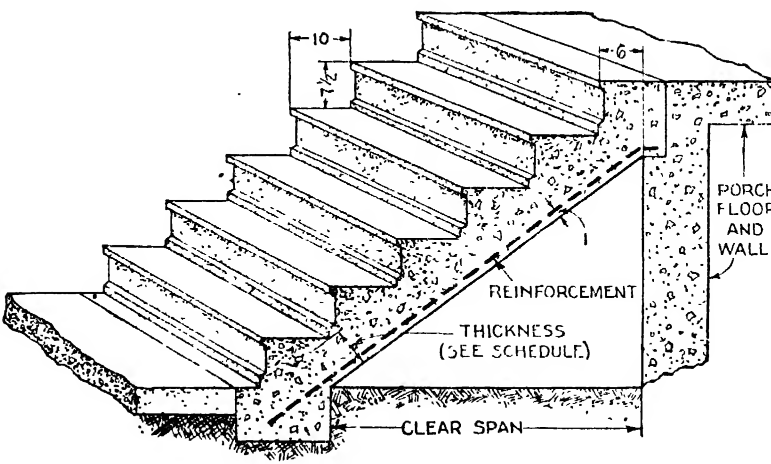


FIG. 5,773.—Self-supporting concrete steps after completion showing reinforcement.

rest must be well compacted so that there will be no settlement and consequent cracking of the concrete. If there be any doubt as to the sustaining power of the soil it would be well to lay a 2 in. layer of concrete first on this slope and then to embed in it ¼ in. rods placed 12 ins. center to center, after which concreting of the steps may be continued. This reinforcing will serve to prevent cracking at the relatively thin section of the concrete where the tread and the rise meet.

Details of both types of step construction are shown in figs. 5,770 to 5,773. The reinforcement required for self supporting steps is given in the following table:

Reinforcement for Concrete Steps

Table of Reinforcement for Concrete Stairs.

Number of Steps	Clear Span		Thickness Slab	Longitudinal Reinforcement	
				Diameter	Spacing Rods
	Feet	Inches	Inches	Inches	Inches
4	2	2	4	¼	10
5	3	0	4	¼	10
6	3	10	4	¼	7
7	4	8	5	¼	7
8	5	6	5	¼	5
9	6	4	6	¼	5
10	7	2	6	⅜	5
11	8	0	6	⅜	4

Watering Trough. The foundation must be firm and solid. If not firm, excavate 18 ins. and fill in with gravel or cinders well packed. Inlet and outlet pipes should be installed before the forms are constructed.

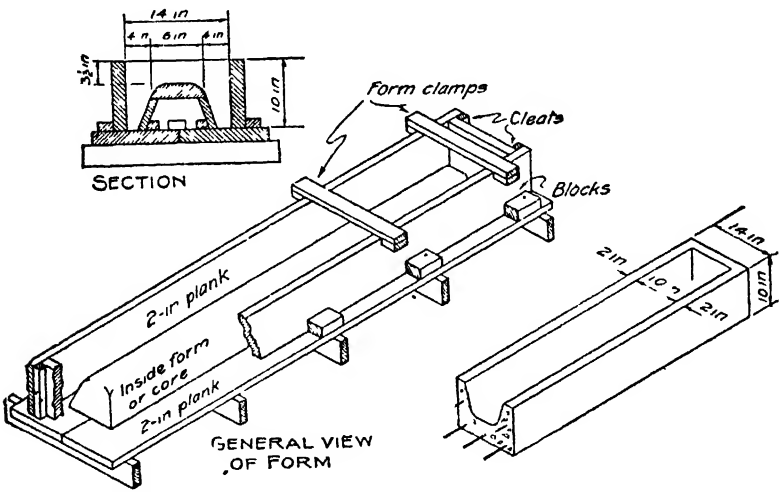
A 1:2:3 mixture is recommended for the concrete.

The trough should be reinforced either with steel rods or wire mesh. Usually, ¼ to ⅜ in. steel rods are used. The number, size and spacing of rods is governed by the size and shape of the tank; the larger the tank the more reinforcement is required.

The walls of the large watering tank, shown in fig. 5,777, are tapered to relieve the wall from pressure of ice should the water freeze. On removal of forms the inside face is given a wash of Portland cement and water mixed to the thickness of cream and applied with a brush to close all pores and insure a water tight job.

Figs. 5,774 to 5,776 show details of forms and placing of the reinforcement.

Septic Tank.—It is simple and easy to build and consists



FIGS. 5,774 to 5,776 – Form for portable concrete watering or feeding form and sectional view of trough in upright position showing reinforcing rod

of a long, water tight cistern, through which sewage passes, very slowly and evenly. Located underground, it is warm and dark, thus affording perfect conditions for the development of the bacteria or germs which clarify and render harmless the sewage. After passing through the septic tank, the sewage is practically free from all suspended matter and has the

appearance of water. From the septic tank this clear effluent is discharged either into a second or filtration chamber, or into an irrigation system.

While the odor from a septic tank is scarcely noticeable, it is nevertheless best to locate it at some distance from the house. Choose a spot easy to excavate so that the top of the tank can be sunk 6 ins. below ground level

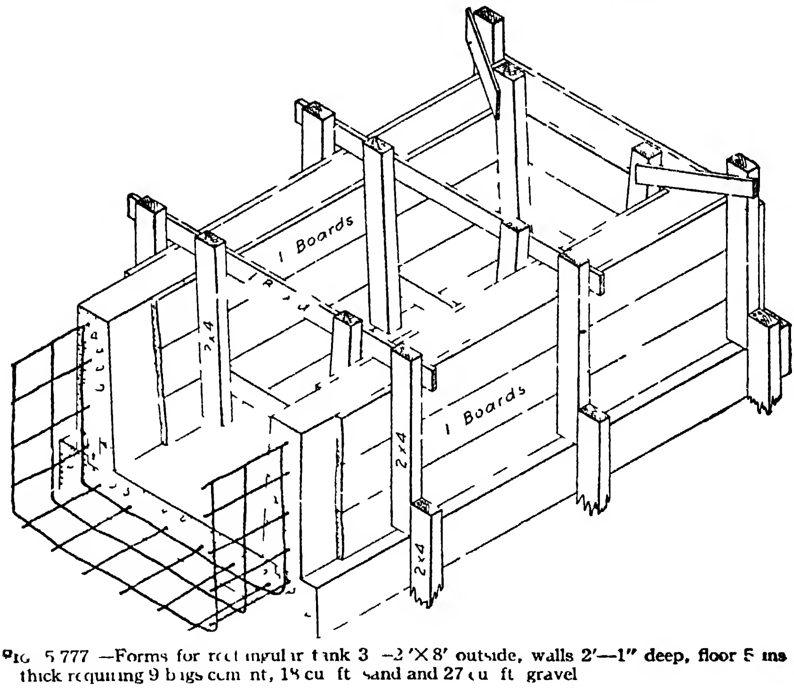
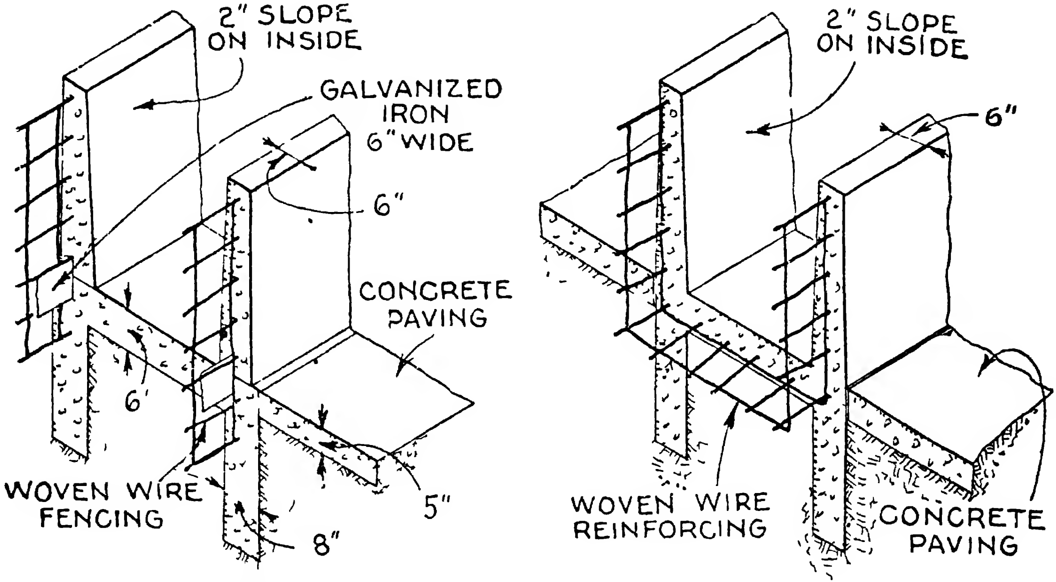


Fig. 5,777.—Forms for rectangular tank 3'-2"X8' outside, walls 2'—1" deep, floor 5 ins thick requiring 9 bags cement, 18 cu. ft. sand and 27 cu. ft. gravel.

and where the lines of drain tile will have sufficient fall to carry off the discharged fluid. The tank should be large enough to hold the entire sewage for one day.

For a family of eight to ten people occupying a house having two bath rooms fitted with the customary appliances in the way of tubs and stationary wash stands and downstairs the kitchen sink, a concrete tank having



FIGS 5,778 and 5,779 —Reinforcing inside slope and pavement for the tank shown in fig 5,777.

two compartments, each 4 feet long by 4 feet wide by 4 feet high, will be required. As shown in fig. 5,780 the other dimensions are also given in the figures

If the earthen walls of the pit stand firm only inside forms will be needed These inside forms are merely boxes made of 1 in boards Two boxes will be required to make two compartments. The outside dimensions of the boxes should be 4 ft square by 4 ft high The boxes or forms will be placed on the freshly laid concrete floor Holes for taking 6 in pipe should be made in the boxes as shown in fig. 5,780. The

holes should be 4 ins. from the top of the box form, measuring from the top of the hole.

Place a 4 in. thickness of concrete in the bottom of the pit to form the floor of the tank. On top of this concrete set the box forms, which should be ready for immediate use. Place the forms so that there is a space of 6 ins. between them and an 8 in. space between them and the earthen walls of the pit. Then commence depositing the concrete for the walls and partition. As soon as the level of the concrete reaches the holes in the forms place in the holes 6 in. pipes as illustrated. Then continue the concreting until even with the top of the forms.

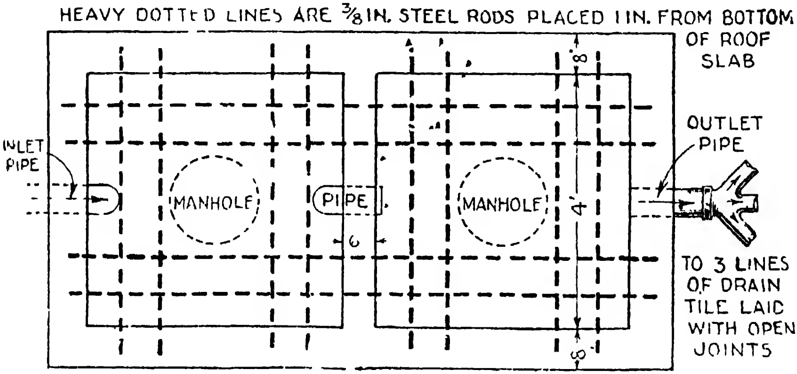


FIG. 5,780 – Septic tank; plan sho[illegible] location of reinforcing rods.

Two ordinary iron manhole frames and covers may be obtained from a local dealer in building supplies. The manhole covers should fit tightly and should not be perforated. The manhole frames should be 10 ins. high so that when placed on top of the forms the upper edge will be even with ground level. If the manhole frame be of less height than this, it should rest on a circular piece of 1 in. board, which is nailed to the top of the form. Since the concrete roof is to be self-supporting, it will be necessary to reinforce it.

Cistern.—Where there is no city water supply and no windmill a cistern is generally provided to store water for laundry and uses other than drinking and cooking.

Figs. 5,782 and 5,783 is a design for a cistern of 5,467 cu. ft capacity.

A, is the cistern and B, a filter tank If built with the filter tank, the filter wall F, is not necessary In this case wall G, is the filter which is the full size of the intersection of B, with the cistern

The filter wall should be of soft brick laid in mortar joints and 4 ins apart This 4 in space is filled with charcoal with enough of it fine to leave no large voids Common brick are very porous which permits seepage of water through them

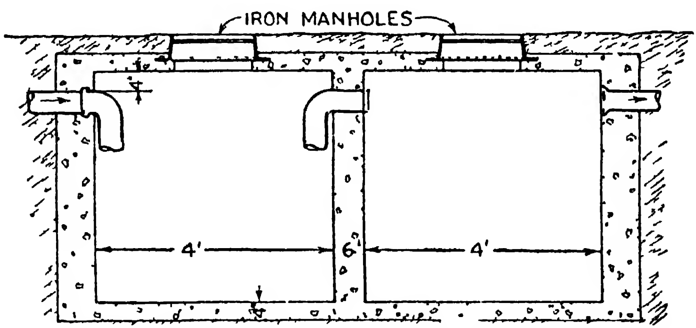
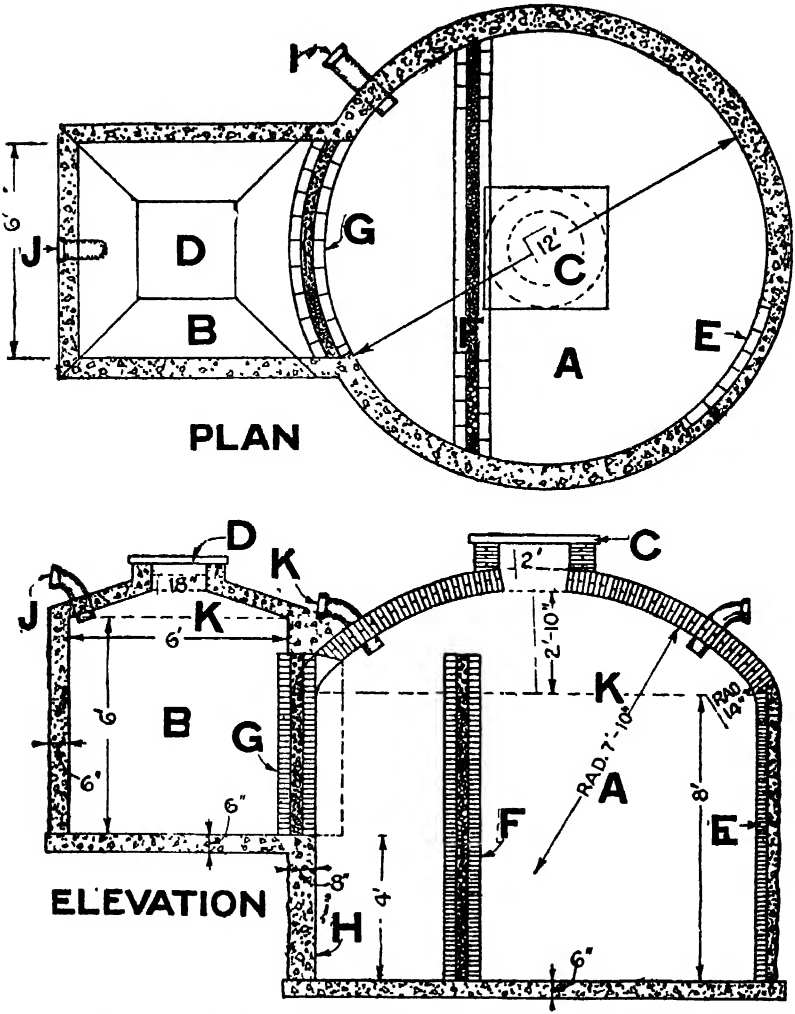


FIG 5 781 —Septic tank, cross section showing location of inlets and outlets.

By building a 4 in brick wall or lining as at E, the concrete may be poured between it and the earth as the wall is being built up thus permitting truing the sides of excavation to the neat size

A reinforcing rod of sufficient size should be embedded in the concrete every 14 ins The latter may be omitted when the concrete is tight against firm earth If built in loose earth, running or sandy soil and forms must be used, then great care must be given to reinforcing

Replacing Old Foundations.—It is frequently necessary to replace wooden or stone foundations that have decayed or deteriorated. Concrete can be placed in small or large quantities and provides a strong and lasting foundation. Fig 5,784 shows the application of concrete for such work.



FIGS. 5,782 and 5,783.—Cistern and filter tank. A, cistern; B, filter tank; C, manhole plate; D, filter tank, manhole plate, E, brick lining; F, filter wall when filter tank is omitted; G, filter tank, filter wall, H, concrete wall, I, inlet, J, outlet, if filter tank be provided; K, outlet when filter tank is omitted.

An old foundation in which the wood is rotting or the stones or bricks are loose, the faulty superstructure should be removed and replaced with a strong durable foundation of concrete. Take great care in supporting the old building while replacing parts or sections of the old foundation. Use jack screws or blocks of wood with wedges driven in to hold them in place.

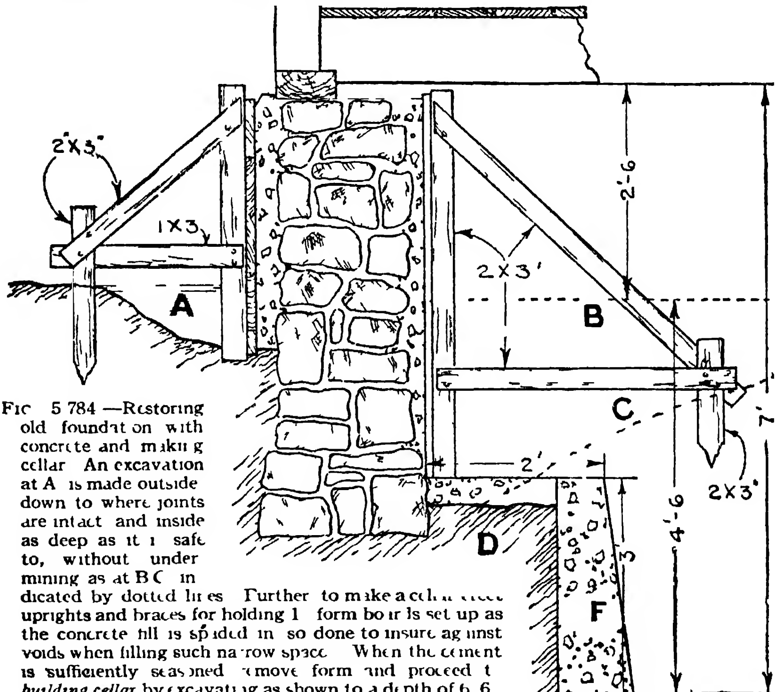
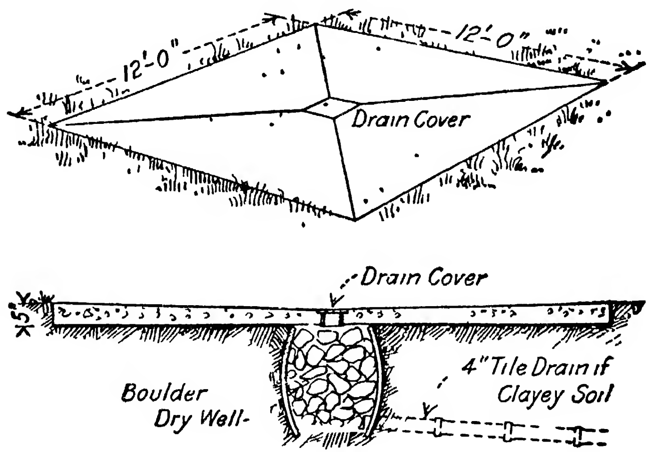


FIG. 5,784.—Restoring old foundation with concrete and making cellar. An excavation at A is made outside down to where joints are intact and inside as deep as it is safe to, without undermining as at B C indicated by dotted lines. Further to make a cellar [illegible] uprights and braces for holding form boards set up as the concrete fill is spaded in so done to insure against voids when filling such narrow space. When the cement is sufficiently seasoned remove form and proceed to *building cellar* by excavating as shown to a depth of 6 6 to 7, careful not to undermine foundation at D by cut setting about 18 or more. If the nature of the earth be intact 18 is enough; if loose or sandy inclined to run then a greater distance may be necessary according to the depth of excavation. Here at D a depth of 3 feet is shown to hold the earth at top and base of old wall intact concrete space F. If it is desirable to improve working conditions the excavation may be level at C, which will require longer and heavier braces for form.

Carriage and Automobile Washing Floor.—Every garage should be provided with a concrete washing floor with drain. It provides a clean place for washing the car and does away with the mud hole near the barn or garage.

Build the floor big enough to take not only the wheels of the rig but the shafts or tongue as well. Make it large enough to give the person who does the washing, room to work on. The average size is about 12 ft. square.

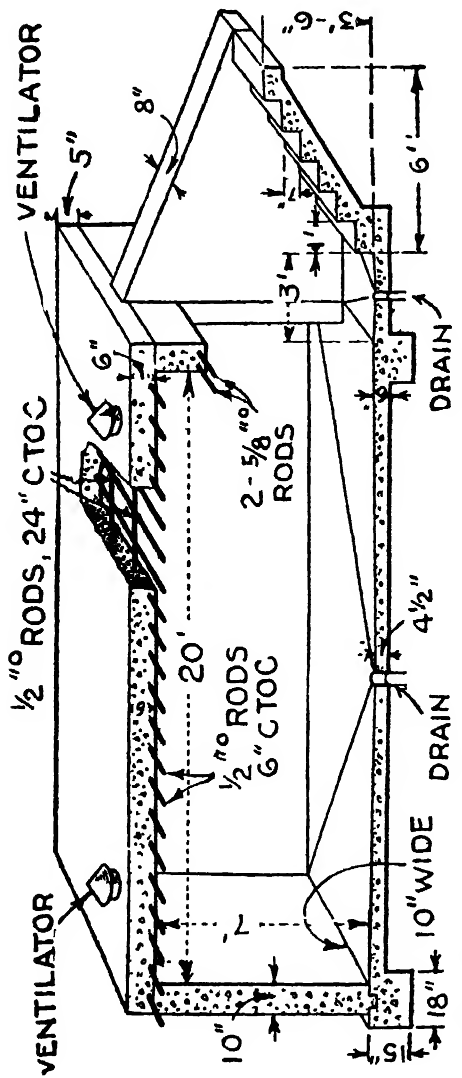
The concrete should be 5 ins. thick throughout. Slope the earth each way toward the center and provide a drain—otherwise the water will run off the sides, taking with it the dirt from the vehicle. A convenient way to build a drain is to excavate, directly in the center, a hole big enough for a large sized barrel. Knock out the bottom of the barrel, set it in the hole, and fill it with field stones. If the soil be clayey so that the water does not



FIGS. 5,785 and 5,786.—Concrete washing floor with drain for washing carriages or automobiles. ***Mixture***. Mix the concrete in the proportions of 1 part Atlas Cement, 2 parts sand, and 4 parts crushed stone or gravel. Finish with a wooden float. ***Quantities required*** to build this 12 ft. square concrete floor requires 13 bags of cement, 26 cu. ft. of sand and 52 cu. ft. of gravel or crushed stone. It should not be more than a day's work for two men.

drain readily from the barrel, it will be necessary to run a drain from the barrel, as shown in figs. 5,785 and 5,786, to some convenient point.

Root Cellar.—For strong roots to be used as winter feed and vegetables and fruits, a root cellar is very desirable. The construction should be waterproof and proof against rats and other rodents. Ventilation openings should be provided so



IG. 5,787 —R

that it will always be warm and dry. The root cellar should be separated from any other building. The side that is entirely exposed should face the south or south-east. Root cellars may be built with flat slab concrete roofs, arched roofs or pitched roofs. Sometimes they are built laregly above the ground; sometimes entirely under ground and covered with earth. The most desirable arrangement is to have the cellar built half below and half above ground.

The root cellar shown in fig. 5,787 can be built without any great difficulty. It is 20 feet long, 10 feet wide, and 7 feet high, inside measurements.

Excavation.—First excavate 6 ins. below the desired floor level of the

root cellar, allowing an extra 10 ins. at either end and sides for the width of the walls. At one end the earth should be dug out to a width of 4 ft. and length of 9 ft., sloping up, allowing for a flight of steps. Each step is to have a rise of 7 ins. and a tread of 10 ins. There should be a 3 ft. landing at the bottom of the steps as shown in the figure.

Floors.—In laying the floor it is better to make it one course concrete, using 1 part cement, 2 parts sand, and 4 parts gravel or crushed stone. Make the floor 6 ins. thick at the sides and 4½ ins. at the center—to provide a slope from all sides to the center for drainage.

A smooth finish can be given to the floor by using a steel trowel or float, but when a wooden float is properly handled it will give you a floor that is smooth enough for all practical purposes.

Walls.—If the soil be reasonably firm it will be necessary to erect forms only for the inside surface of the walls allowing the earth to take the place of the outside form. Use a mixture of 1 part cement, 2 parts sand, and 4 parts gravel or crushed stone. The concrete should be placed in layers 6 to 12 ins. deep, and should be well spaded next to the forms. Carry on the work continuously, if possible: but if it be necessary to place concrete on successive days, clean off the surface of the concrete placed previously and treat it so as to provide a good bond between it and the new concrete.

Roof.—The roof may be constructed of either wood or concrete. The wooden roof is simple of construction. The concrete roof is a permanent sanitary covering that will not rot or break down and is recommended for these reasons The roof should have two ventilators as shown in the figure.

At least a week should elapse after the floor and walls have been poured before you begin the construction of the roof. This is the only part of the structure that need be reinforced. For reinforcing use ½ inch diameter round rods Place them 1 in from the bottom of the roof, and have them 6 ins. apart, running crosswise, and 2 feet. apart running the long way of the cellar. Use a 1:2:4 mixture for the concrete. Make the roof 6 ins. thick at the center and 5 ins at the side to provide a slope. The forms and supports of the roof should remain in place at least three weeks under favorable conditions before removal.

The amount of materials required for a concrete cellar 20 ft. long, 10 ft. wide and 7 ft. high, inside dimensions, are 175 bags of cement, 350 cu. ft. of sand, 700 cu. ft. of gravel or crushed stone, 40 rods, 11 ft., 4 ins. long, 5 rods, 21 ft. 6 ins. long, all ½ in. diameter.

This same type of structure is sometimes used for an incubator cellar

Deep Patches in Concrete Pavements.—For patching holes more than an inch deep, permanent repair is insured by trim-

FIG 5 788 —Deep patching *1st step:* Chipping edges of old pavement and tamping sub grade

ming the hole to a depth of not less than 3 ins., squaring up the edges and filling with new concrete. The edges of the hole should be trimmed with a cold chisel to make a vertical square edge for a depth of _ in. below the surface of the pavement.

The old concrete should be trimmed away until perfectly sound material is reached. The hole then should be thoroughly cleaned and the edges and bottom wetted. Do not leave water standing in the hole. Mix new concrete, using as nearly as possible the same materials as used in the original pavement and in the same proportions, except that the mixture should not be leaner than 1 part Portland cement, 2 parts sand, and

FIG. 5,789 —Deep patching. ***2nd step:*** Mixing new concrete on the pavement near the cut to be filled. A stiff mixture is best.

3 parts of pebbles or crushed rock. Use pebbles or crushed rock of a maximum size corresponding to about half the depth of the hole to be repaired. When mixing the concrete, do not use any more water than absolutely necessary to moisten the mixture and to hydrate the cement.

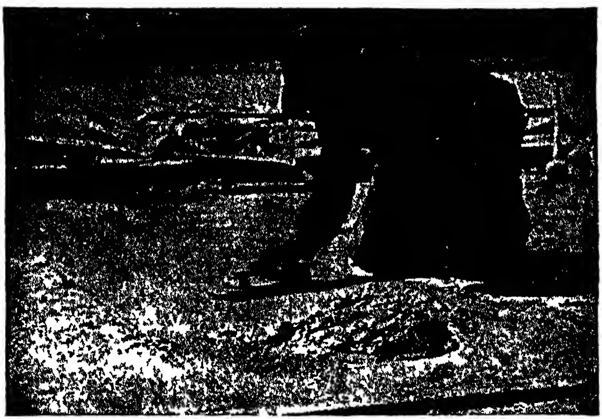
The mixing should be very thorough and should be done immediately before the concrete is to be used. Place the concrete into the hole to be patched, tamping it firmly against the

sides and bottom of the hole so as to leave no cavities. The hole may be slightly over filled, as the subsequent treatment will reduce the volume of new material. After the material has been thoroughly tamped, allow it to stand for 5 to 30 minutes. The tamping should then be repeated and again repeated at intervals of 5 to 30 minutes so that it is tamped at least three times 5 to 30 minutes apart, before the final surface finish is given. The interval between tampings will be controlled by

FIG 5,790 —Deep patching *3rd step:* Wetting the edges of the old concrete before filling in the new No water should stand in the sub grade

FIG 5,791 —Deep patching *4th step:* Thoroughly tamping the newly placed concrete Repeat tamping three times with intervals between

the rate at which the cement hardens, and the air temperature. The concrete will harden more rapidly on hot days than on cool ones, and the treatment should be governed accordingly. This repeated tamping is important as it takes up all of the shrinkage which occurs as the cement begins to set and insures complete filling of the cavity. After the last tamping, the surface should be worked evenly with a wooden hand float, special care being taken to produce a good finish at the edges



FIGS 5,792.—Deep patching. ***5th and last step:*** Finishing the new concrete with wooden hand float. The last step, curing the new concrete by covering with moist material for from 5 to 20 days.

of the patch and an exact surface contour conforming to the adjacent pavement. After finishing the surface, cover the fresh patch with damp canvas or burlap, until the concrete has thoroughly hardened. Then cover the patch with damp earth three or four inches deep. During hot or dry weather keep the earth cover moist by wetting down twice a day. Keep the moist cover on for at least five days; the traffic should be kept off the patch for ten to twenty days, if possible, so the fresh concrete may harden properly. If these suggestions be followed carefully and proper materials used, a patch will be

FIG. 5,793.—Concrete work in cold weather. 1. A coke burner hot water heater is very convenient for heating water close to the mixer.

FIG. 5,794.—Concrete work in cold weather. 2. An oil burning heater projected into the mouth of the mixer heats the materials sufficiently to keep the concrete from freezing, providing other precautions are used after placing in the forms.

produced which will unite perfectly with the old concrete and which can hardly be distinguished from the surrounding pavement. Substantial barricades should be placed to keep vehicles away from new patches during the hardening or "curing"

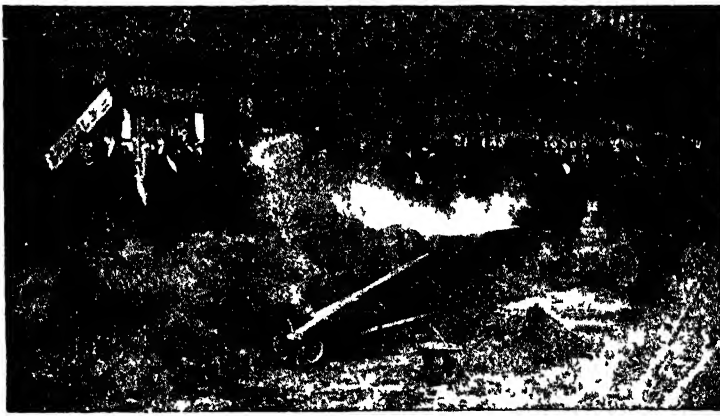


FIG 5 795 —Concrete work in cold weather 3 Repairing street car pavement at a busy corner in Chicago, sand and gravel being heated in a metal culvert and water in a flat tank

FIG 5 796 —Concrete work in cold weather. 4. Method of heating water for concrete work shown in Fig 5,795

period. Clearly legible warning signs should be posted both on the barricades and in conspicuous positions beside the road three or four hundred feet each way from the repaired spot. Post red lanterns at night, chained and padlocked to the

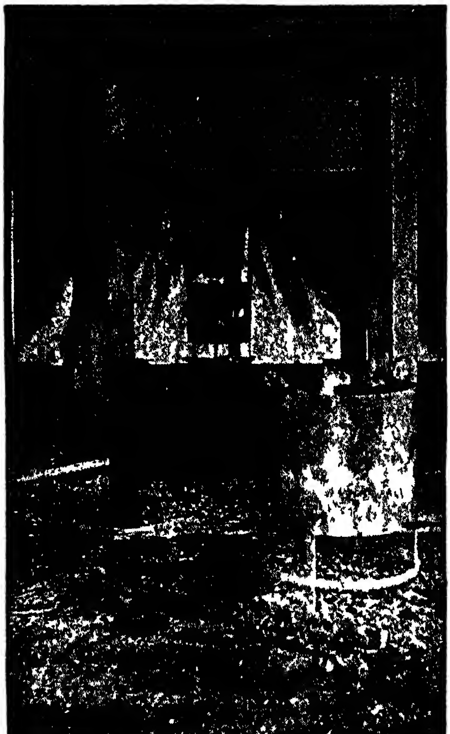


FIG 5,797 —Concrete work in cold weather 5 Salamanders under forms and behind vas furnish heat for freshly placed concrete and maintain constant temperature

barricade, in sufficient number to indicate clearly the obstruction.

When it is not possible on account of weather or traffic conditions to

make a permanent patch a temporary repair may be made with a bituminous mixture. The spots to be repaired should be first trimmed out to sound concrete, leaving square, vertical edges all around the hold and all

FIG. 5,798.—Concrete work in cold weather 6. Steam jets placed in aggregate pile to keep the material from freezing. Frozen lumps may also be thawed out by the use of these jets.

FIG. 5,799.—Concrete work in cold weather 7. Another method of heating materials by the use of a coal fire in a discarded hot water boiler seen in the lower left hand corner.

NOTE.—*Frozen concrete.* Many accidents are caused by mistaking frozen concrete for properly hardened concrete because it may have the same ring when struck with a hammer. A reliable test for determining whether concrete is frozen instead of properly hardened is to apply hot water or steam to the surface. If frozen it will soften, but if properly hardened it will be unaffected by the heat.

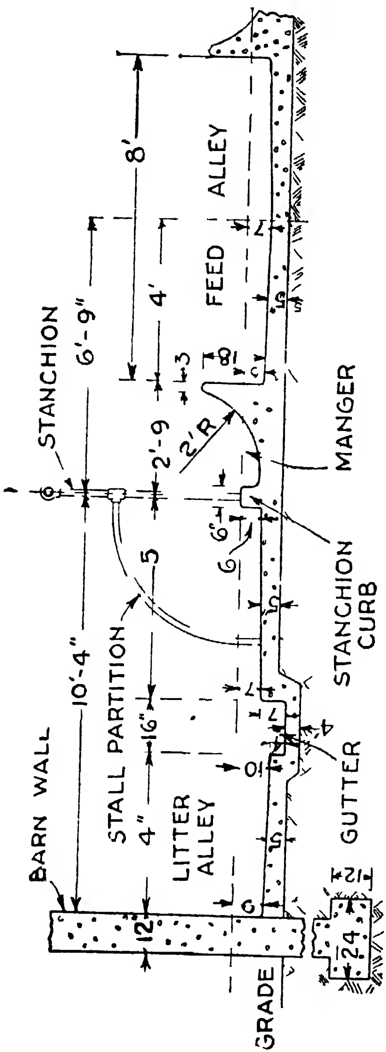


FIG 5,800 —Dairy barn construction 1 Cross section of dairy barn floor

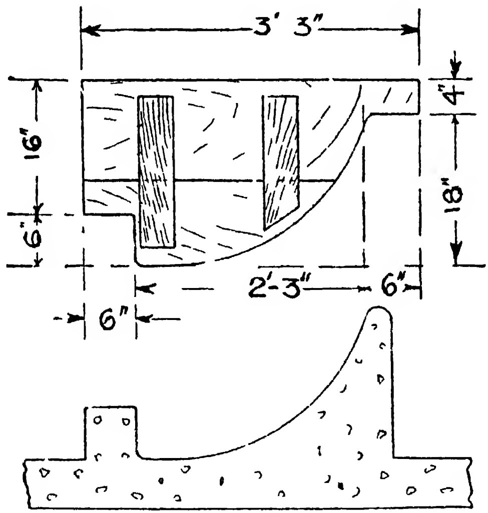
loose material cleaned out Paint the sides and bottom of the hole with a thin coating of bitumen.

For holes from 2 to 3 ins. deep, a bituminous mixture may be prepared by using a well graded combination of sand or crushed rock screenings and crushed stone. Do not use stone over 1½ depth of the hole. The bituminous mixture may be prepared on a mixing platform or in a mixing box.

Either the "hot" or "cold" bitumen may be used for this purpose Use just enough to cover every particle of stone and sand in the mixture and work the mass thoroughly with shovels until this is accomplished Such a mixture may be prepared in stock quantities and stored for several days or weeks, if necessary taking care that it is completely filled and that the mixture is firmly tamped against the edges When the hole has been tamped level full the surface should be given a spray or paint coat of the bitumen and covered with a liberal application of dry sand or stone screenings

If the patch do not extend entirely through the thickness of the concrete slab and the work be carefully done, a temporary repair of this kind will hold up under medium traffic for several months.

Concrete Dairy Barn.—The dairy barn is a place where the most perishable and easily contaminated human food is produced. This food is largely used in an uncooked state, for



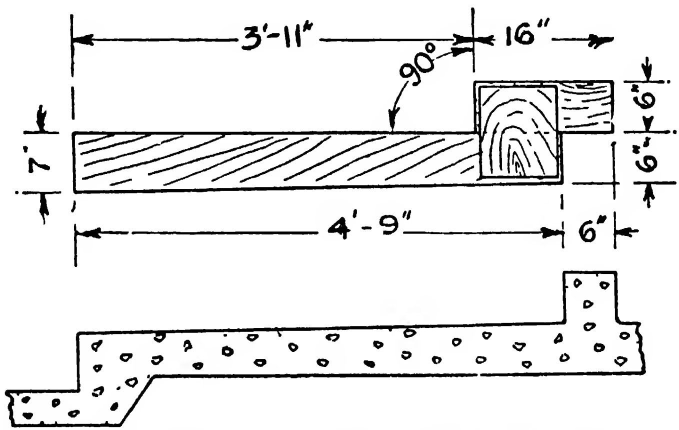
FIGS 5 801 and 5 802 —Dairy barn construction 2 Template for manger and section of manger

invalids, infant feeding and the like, hence the maximum amount of cleanliness should be obtained in every phase of milk production.

Stalls and other living quarters for the cows must permit of frequent and thorough cleaning, and as far as practicable, the avoidance of dust. Floors, walls and passageways should be even, free from cracks and crevices which collect dirt, and these surfaces must be impervious to water so as to allow

washing and scrubbing when necessary. Health standards no longer admit of half-way measures. The dairy buildings must be sanitary.

The value of concrete in this connection is beyond question. Inexperienced persons sometimes raise the objection that concrete is too cold or too slippery for stalls and stable floors. These criticisms are not well taken, because the complaint is not against the material, but against its incorrect use.



FIGS. 5,803 and 5,804.—Dairy barn construction 2. Grade board for stall platform.

A concrete floor can be so finished—roughened—that it will afford excellent traction, and not be the least bit slippery. Such a roughened surface, easily put on, will retain the bedding and thus prevent the cow's body coming into direct contact with the floor. Or, if a greater first cost be not out of the question, the stall platforms can be overlaid with a material such as cork brick or creosoted blocks of wood.

The standard width of a cow stall is 3 ft. 6 ins. For small cows a width of 3 ft. is sometimes used, but this is really too narrow and not to be recommended. The average length of a stall platform, from gutter to manger, is

4 ft. 8 ins. For extremely long cows this measurement is increased to 5 ft. or longer.

The objection to an unnecessarily long platform is that the droppings will fall in the stall proper, instead of in the gutter, which will result in the cows being soiled when they lie down. Inasmuch as it is desirable to have stalls to accommodate both short and long animals in the same barn, a good plan is to make the platforms on one side of the barn 5 ft. long, and on the other side 4 ft. 6 ins., or the gutters may be run at a slight angle from the manger line, which will provide a gradual increase in the length of each stall.

The manger should be given a slight fall, much the same as the barn floor is pitched, to drain off any surplus water when the cows are watered in the manger, or when the manger is flushed with water in cleaning.

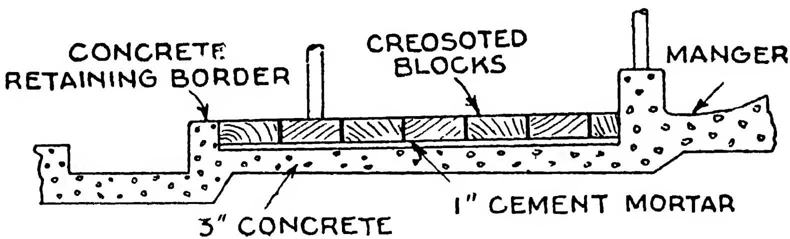


FIG. 5,805.—Dairy barn construction 4. Section through paved stall.

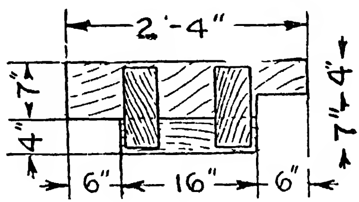
The gutter should have sufficient pitch to carry off the water when the floors are washed down, and be fitted with an adequate sewer pipe and strainer. This outlet should be equipped with a shut of to prevent the escape of liquid manure If the passageways, mangers and gutters be all given the same pitch, no difficult measurements will be encountered in laying the barn floor. It is then a simple problem of giving the entire floor a gradual slope toward one end of the building, or of starting in the center of the building and sloping toward both ends.

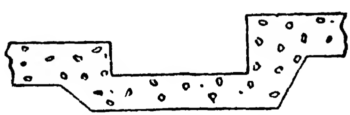
The widths of the passageways along the walls and in the center will depend upon the space available. A convenient entry cannot be narrower than 4 feet If the cows face in and the feed be handled by an overhead carrier, a central passageway four feet six ins. wide is ample, though five

feet would be better: whereas if the feed must be hauled into the barn with a team. a driveway eight feet between the mangers is necessary. Strictly speaking, stall partitions are unnecessary when the cows are held by swinging stanchions, as in the modern barn, but most dairymen prefer them. for the protection of the cows and the milkers. Such a partition need not be large.

The ground on which the floor is to be built should be excavated, and the cinder or other suitable foundation material tamped into place at the correct levels, to conform as much as possible to the contour of the finished floor, which is about five inches thick. The manger is started first.

Erect forms –two inch planks are best because they require little or no





FIGS 5,806 and 5,807 –Dairy barn construction 5. Template for gutter and section of gutter

additional stiffening -for the stanchion curb, and for the front of the manger where it joins the passageway. All stanchion supports and the bolts for the yokes are then located and marked on the forms. Concrete to allow for about five ins. of manger bottom is then poured into place and brought to the general shape of the wooden manger templet, shown in fig 5,801, but half an inch lower than the finished surface of the manger Concrete for this portion of the floor should be fairly stiff, so that the inside plank which forms the stanchion curb can be removed a short time after the concrete is placed, and the manger brought to its finished state by the application of a facing mortar, smoothed with a steel trowel.

After the mangers are completed, the laying of the stall platforms are begun, which is similar to ordinary sidewalk construction. A single plank form placed in the gutter trench, with the top of the plank set to a line that will give a one in slope to the stall platform is all that is required

A surface mixture is not needed for this part of the work. The regular mix of a fairly wet concrete, brought to a true grade by means of the grade board, as shown in figs. 5,803 and 5,804, will answer very nicely, whether the platform is to be left with a concrete surface or overlaid with other material. If, however, the stall platforms are to be paved with a facing material, provision must be made, as in fig. 5,804 for the thickness of the paving and for the concrete nosing or retaining border. The surface of this part of the work should be finished or dressed up with wooden trowel or float, so that it will set with a roughened face. If a steel trowel be used the surface will be smooth, unless it is subsequently brushed or scratched, as with a broom.

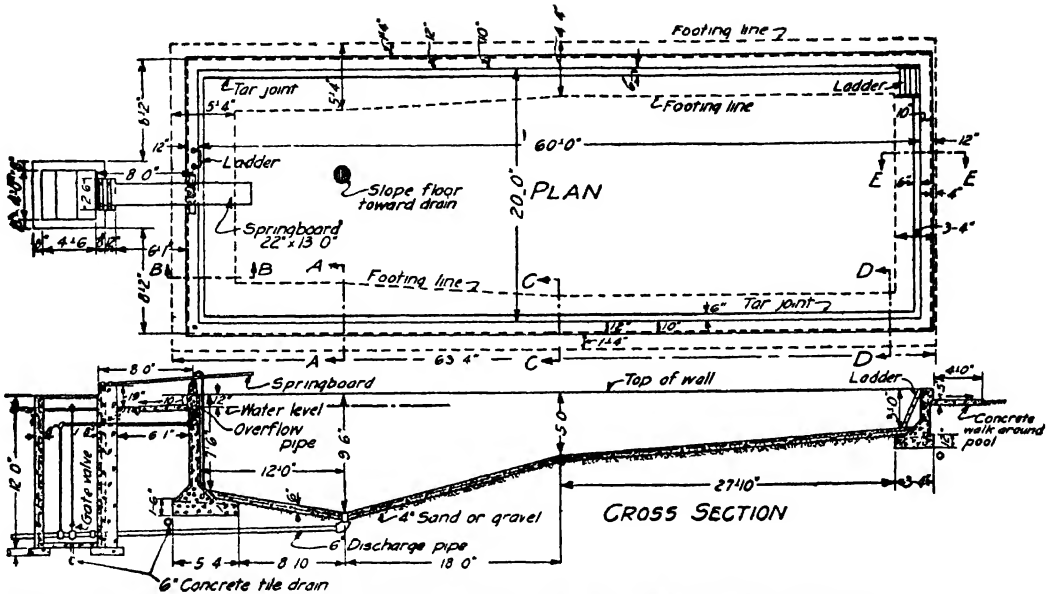
The central passageway and the passageways at the sides of the barn are laid after the fashion of the stall platforms, except that the feeding alley is finished with a smooth surface. since the cows seldom, if ever, have occasion to walk here. In the case of feed alleys, no form planks are required. The concrete is placed from manger to manger, or from manger to the barn wall. In the manure alleys a single plank form is required, with the top edge set to a line that will give the correct height in relation to the stall platform. The gutters are poured last, which consists in placing a four inch thickness of concrete in the trenches left between the stall floors and the passageways This part of the work is easily brought to the desired grade by means of a wooden template, shown in figs. 5,801 and 5,802, which is dragged back and forth, supported by shoulders which rest on the uneven heights of the stall floors and passageways.

Surface Finishing Methods for Concrete Pavements.—The following instructions cover approved methods for this kind of work.

Striking off for Contour.--Fig. 5,815. Concrete should be mixed with the least amount of water that will produce a workable mixture. After it has been placed on the subgrade it is spread to the approximate contour of the desired cross section with shovels.

On pavements not over 20 ft. in width, it is practical to use a template, or strike board, cut to the proper crown of the finished section, to strike off and compact the concrete. If the strike board be made of wood, its edge should be shod with steel. A heavy strike board, weighing not less than 15 lbs. per lineal ft., is recommended. It must be strong enough to prevent sagging. When pushed forward, it carries excess material before it and compacts the concrete, leaving this with the proper contour ready for the final finishing operations.

In some cases two strike boards are used. The first one should be 3 or 4

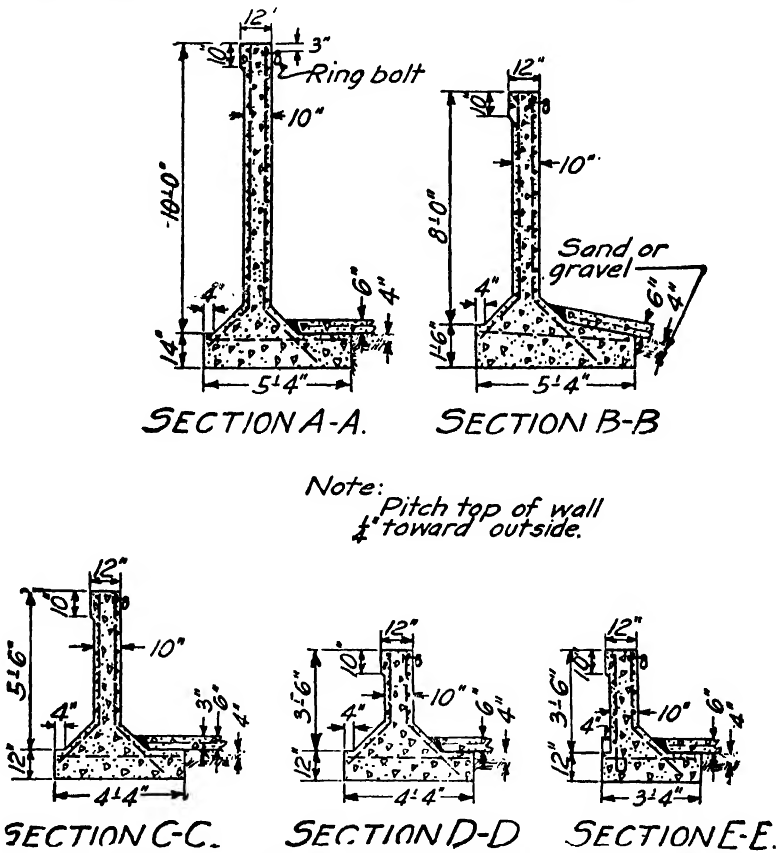


FIGS. 5,808 and 5,809.—Plan and elevation of small concrete swimming pool, showing details of construction.

ins. wide and is used to tamp as well as to strike off the concrete. This template is cut so as to leave about ½ in. surplus concrete at the center. The second strikeboard is lighter and is moved continuously over the surface, taking off the slight surplus material left by the tamping board

Contour by Luting.—Fig. 5,816. On pavements wider than 20 ft. the concrete may be distributed by "luting." The lute resembles a toothless rake and is operated so as to spread the concrete to

very nearly the contour of the finished section. The operator is guided by steel pins set at intervals across the subgrade. Lugs near the tops of these pins mark the elevation to which the concrete is to be brought. By using a straight edge, as shown in the illustration, the operator is able to distribute the concrete very closely to the exact grade. Any slight unevenness left in the surface after it is luted is removed by subsequent finishing operations.



FIGS. 5,810 to 5,814.—Various wall sections of the small concrete swimming pool shown in figs. 5,808 and 5,809.

Floating with Long Handled Floats.—Fig. 5,817. The use of long handled wood floats immediately following the lute smooths the concrete and takes out irregularities. The float is moved backward and forward, its forward edge being slightly raised. Care must be taken to avoid leaving a depression at the end of the stroke. The wood float brings mortar to the surface, imbeds and covers all particles of coarse aggregate and removes all longitudinal irregularities.

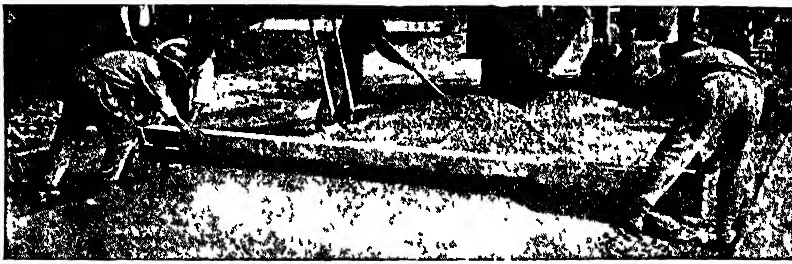


FIG. 5,815.—Finishing concrete pavements 1. Striking off for contour.

FIG 5,816 —Finishing concrete pavements 2. Contour by luting.

Floating with a Darby.—Fig. 5,818. In this illustration the pavement surface is being finished by means of a long wood float sometimes called a "darby " having a handle similar to that on the ordinary float used for sidewalk finishing. The float is operated with a circular fanlike motion from a bridge spanning the pavement When the section of the pavement that can be reached with the float is finished, the bridge is moved forward.

Finishing with Rope Operated Float.—Fig 5,819 The float board shown here is made of a 2×12 in plank, 10 to 12 ft long, the lower longitudinal edges of which are rounded to a radius of about 1 in The board is pulled backward and forward across the pavement by ropes attached to the float as shown This device is used after the concrete has been struck off and tamped with a strikeboard or after the concrete has been luted and smoothed with a long handled wood float

Fig 5 817 —Finishing concrete pavements 3 Floating with long handled floats

Fig 5 818 —Finishing concrete pavements 4 Floating with a darby

Finishing with Belt.—Fig 5,820 After the concrete has been struck off and floated, the final finish is given by belting Two or more applications of the belt are recommended For the first application vigorous strokes at least 12 ins long are used and the longitudinal movement along the pavement is slight The second application is given immediately the

water glaze or sheen disappears, and the stroke of the belt is not more than 4 ins. while the longitudinal motion is much greater than during the first belting.

Proper Sequence of Striking Off, Floating and Belting.—Fig 5,821. This view shows the proper sequence of finishing operations. In the foreground is the heavy template, then follow the long handled floats, and finally the belt. The men in foreground are standing on a finishing bridge.

FIG. 5,819 —Finishing concrete pavements 5. Finishing with rope operated float.

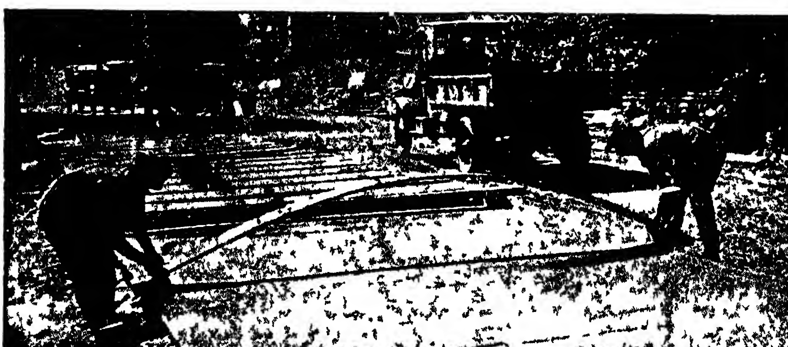


FIG. 5,820 —Finishing concrete pavements 6 Finishing with belt.

Construction and Care of Belts.—Fig. 5,822. Belts used for finishing concrete pavements are usually made of canvas or rubber belting. They should be not less than 2 feet longer than the width of the pavement.

Some sort of handle should be provided at each end of the belt. When not in use, the belts should be carefully cleaned and rolled to prevent the edges from curling, and be kept wet

Finishing with Wood Belt.—Fig 5,823 The "belt" illustrated here is made of narrow flexible wood strips held together by cross strips of wood In using this device, care must be taken to keep the edges from

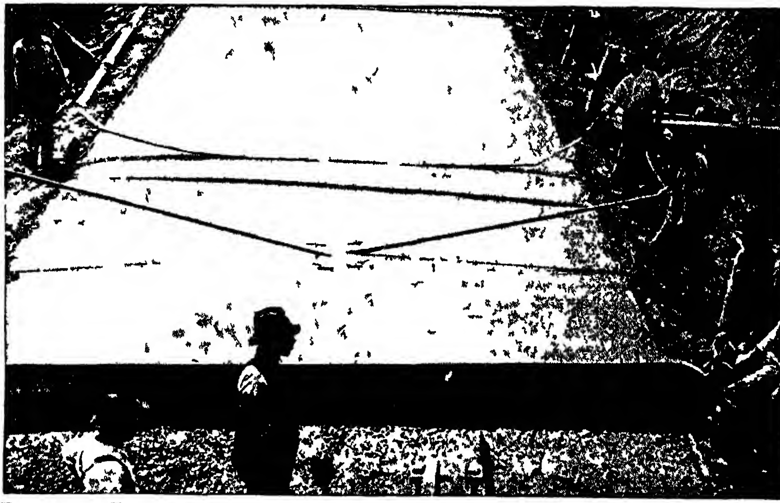


FIG 5 821 —Finishing concrete pavements 7. Proper sequence of striking off, floating and belting.

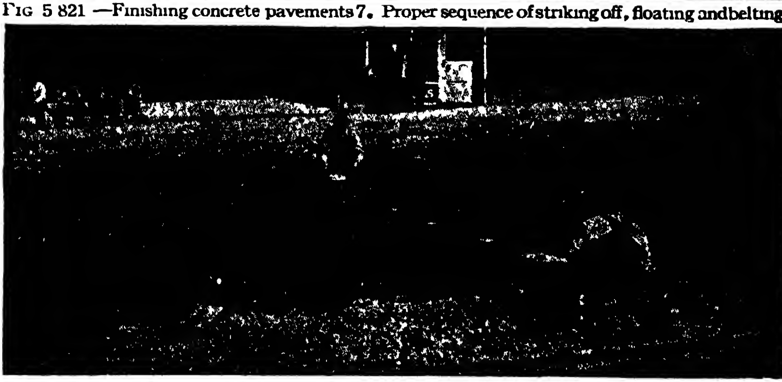


FIG. 5,822 —Finishing concrete pavements 8 Construction and care of belts.

digging into the soft concrete. To avoid this the belt must be held flat on the surface.

Finishing with Longitudinal Wood Float.—Fig. 5,824. A long wood face float, operated longitudinally has been used with success in California. It has the effect of ironing out any transverse waves that may have

FIG. 5,823 —Finishing concrete pavements 9. Finishing with wood belt

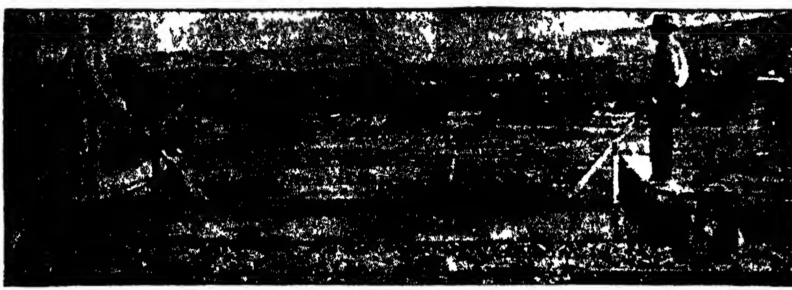


FIG. 5,824 —Finishing concrete pavements 10. Finishing with longitudinal wood float.

FIG. 5,825 —Finishing concrete pavements 11. Finishing with a garden hose

escaped the template or transverse floating. The longitudinal float is 15 to 20 feet long and is operated by two men working from parallel bridges spanning the pavement. It is drawn back and forth, with a slow easy motion, gradually moving from one side of the pavement to the other. By moving the bridges forward half the length of the float each time, the longitudinal grade of the pavement is certain to be without defects.

Finishing with a Garden Hose.—Fig. 5,825. An ordinary garden hose, if properly used, will produce an excellent finish. After the pavement has been struck off or luted and floated with one of the types of floats pre-

FIG. 5,826.—Finishing concrete pavements 12. Finishing at joints.

viously described, the hose is drawn forward slowly as shown in this illustration. The hose is drawn forward and back over the pavement several times, filling up the low spots and cutting down the high places, until the desired finish is secured.

Finishing at Joints.—Fig. 5,826. Special care must be exercised in finishing the pavement at joints. Unless the elevation of the surface on both sides of the joint is exactly alike, a bump will result. With a split float the pavement on either side of the joint material can be finished to

the same elevation. A notch is left in the center of the float to provide clearance, for the joint material which projects above the surface of the pavement. This illustration shows a practice which should not be tolerated—walking on the surface of the concrete. Always provide the finishers with a bridge.

Checking with Straightedge.—Fig. 5,827. Before the concrete nas

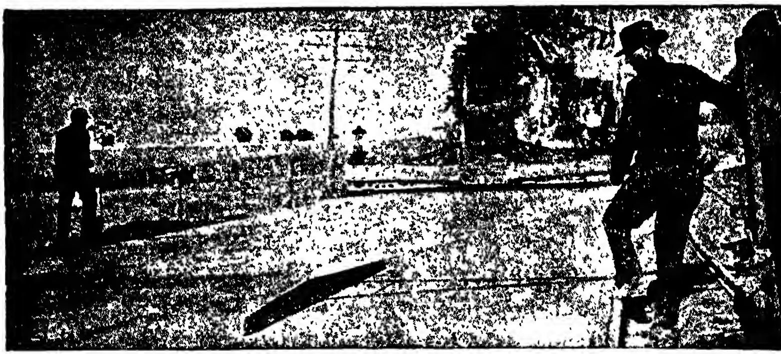


FIG. 5,827.—Finishing concrete pavements 13. Checking with straightedge.

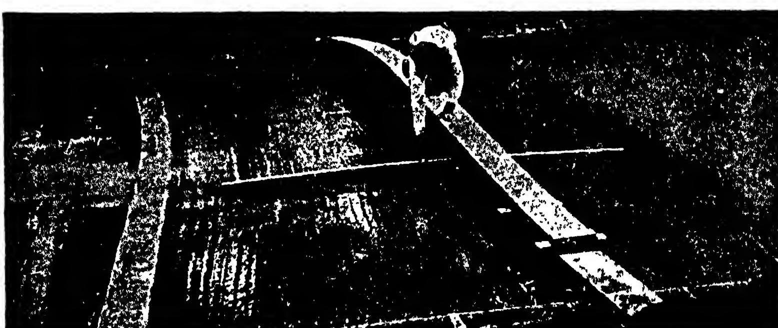


FIG. 5,828.—Finishing concrete pavements 14. Use of straightedge important detail.

hardened beyond workability, the surface of the pavement must be checked with a 10 foot straightedge placed on the pavement parallel to the center line of the road or street. The straightedge may be provided with a long handle, as shown, and manipulated from the side of the road. The finished surface should not vary more than ¼ inch from the true surface as disclosed

by the straight edge. Any irregularities should be corrected at once, while the concrete is still workable. Usually such irregularities can be corrected by the finisher if discovered in time. After the concrete has hardened, corrections are difficult and expensive

Use of Straight Edge Important Detail.—Fig. 5.828 The use of a straight edge for checking the surface of a pavement is specified on highway work in most states The allowable variation is usually ¼ in. in 10 feet. Each year highway officials are placing greater emphasis on the need for smooth riding surfaces and the highway builder must recognize the importance of this detail of construction.

Asphalt Blocks.—These are usually laid on a concrete foundation, upon which is spread a bed of Portland cement mortar ½ in. thick, which is smoothed off with a template to a true and even surface. Upon this mortar bed, and before the cement sets, the blocks are laid with close joints and uniform top surface, the joints being broken 4 ins., as shown in fig. 5,829. After being laid, the blocks are given a light coat of sharp fine sand, well broomed into the joints; if conditions require it, the joints may be grouted or filled with asphalt.

For a water proof construction such as is often required on bridges, over vaults, etc., the concrete foundation is covered with layers of asphalted felt, upon which the mortar bed is laid directly and smoothed off with a template as in fig. 5,830.

NOTE *How to patch a concrete floor.* Cut down the worn place at least 1½ in. This cutting should be carried into the strong unbroken concrete and the edges should be cleanly undercut The bottom of the cut should then be swept out, clean blown out with compressed air or a pair of bellows, if available, then thoroughly wet and scrubbed with a broom. In this way small loose particles of broken material which the chisel has driven into the surface are removed A grout made of pure cement and water about the consistency of thin cream should be scrubbed into the pores with a broom or brush, both at the bottom and sides of the cut Following this a stiffer grout, about the consistency of soft putty, should be thoroughly compressed and worked into the surface, which has already been spread with grout. Finally, before the grout is set, a mortar made of one part cement to one part crushed stone or gravel consisting of graded sizes from ½ in down to the smallest excluded dust, should be thoroughly mixed and put in place, then floated to a proper surface Cover with wet bagging, wet sand, sawdust, or other available material All trucking should be kept off and the surface kept thoroughly wet for at least one week or ten days If a particularly hard surface be required, 6-penny nails are sometimes mixed with the mortar and other nails stuck into the surface when the patch is finished This will produce a surface which is extremely hard and durable.

The blocks are then laid upon the mortar bed and the joints grouted. This method of construction combines reliable waterproofing with great durability, and is far superior to the old method of laying the blocks directly on the asphalted felt and running the joints with asphalt

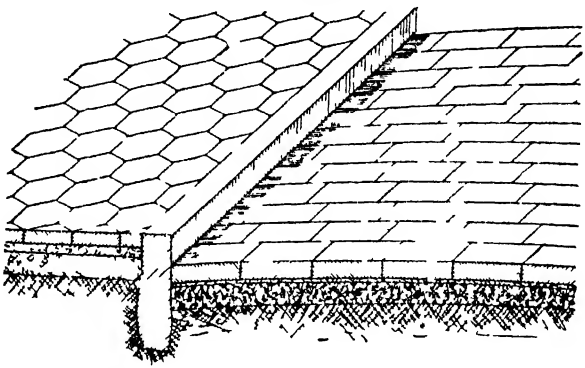


FIG 5 829 —Asphalt block wall construction

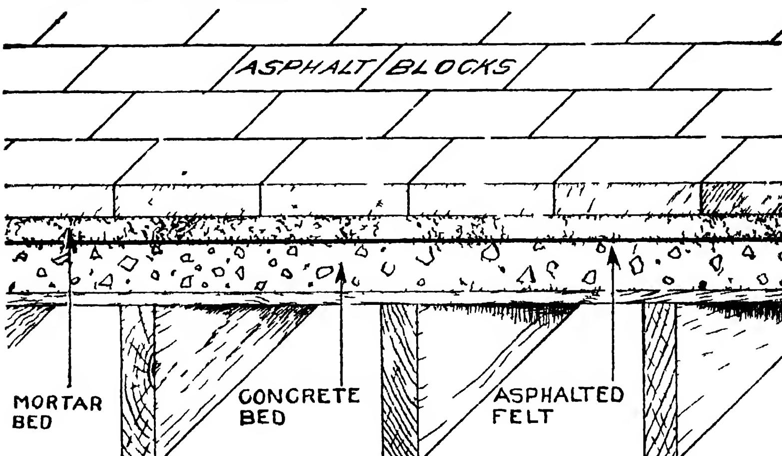
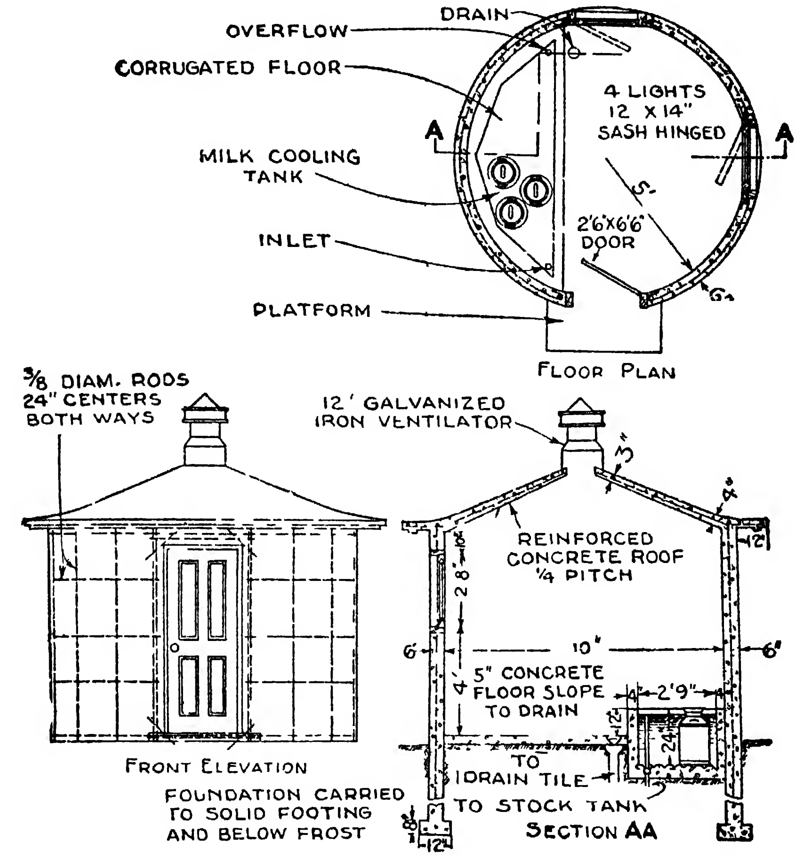


FIG 5 830 —Asphalt block roadway on bridge with waterproofing of asphalted felt



FIGS. 5,831 to 5,833. Details of circular concrete milk house.

NOTE.—*Cement in a silo* or in any other building can be made and kept airtight, rat-proof, waterproof and fireproof without the expense and with less depreciation than a structure of any other material so far known. Cement silos can be made in various types—of cement staves, cement block or monolithic. It is desirable to have a competent contractor with experience in cement work build the silo. It is not impossible, however, for a farmer himself to build a small or medium sized silo of cement. It is merely necessary that the established principles of good cement construction be closely followed. Excavating should be deep enough to bring the footings below possible frost penetration and rest them on a soil that is dense and firm. A drain is necessary silo. Reinforcing is necessary in a monolithic silo, according to its dimensions.

Milk Houses.—In order that milk may be delivered to the consumer in a sweet, clean, sanitary condition, it must be kept cool until it can be taken to market. Milk is probably more susceptible to contamination than any other food product It quickly absorbs disagreeable or objectionable odors to which exposed.

A small milk house separated from the barn is necessary so that milk will not be tainted by stable odors. Concrete construction, either monolithic or block, makes an ideal milk house. Such a structure should be conveniently located, which in most cases will be somewhere between the barn and the house and near a supply of water and the ice house, if there be one on the farm.

The accompanying illustrations, figs. 5,831 to 5,833, show two types of concrete milk houses. one circular and one rectangular.

A round milk house like the one shown can be built by using the commerical forms commonly employed in building circular tanks or silos. A circular milk house can also be built by using the type of concrete block used for block silos. Both of the milk houses shown in the plans mentioned have been purposely designed small so that they will not provide storage place for tools and implements of various kinds which would soon clutter up the place and make it unsanitary. The milk house should be used for handling and caring for milk only.

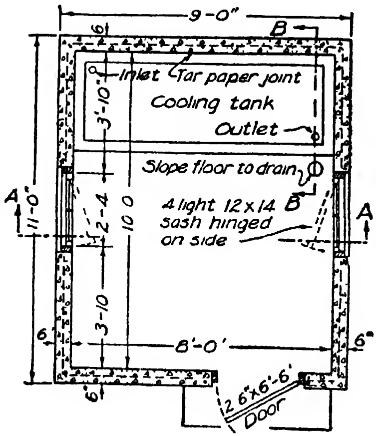
Circular Milk House

(Materials required)

Cement	61 sacks
Sand	5½ cubic yards
Pebbles or broken stone	8 cubic yards
Reinforcing steel	805 feet ⅜ inch round rods

Concrete Mixtures

Walls and foundation	1:2½:4
Roof, floor and tank	1:2:3



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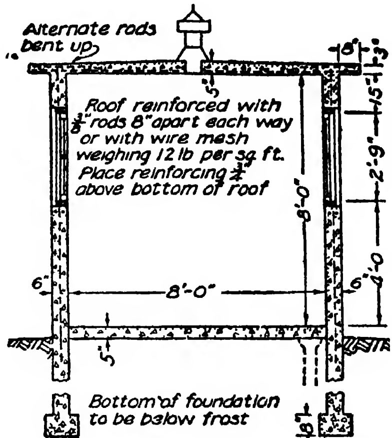
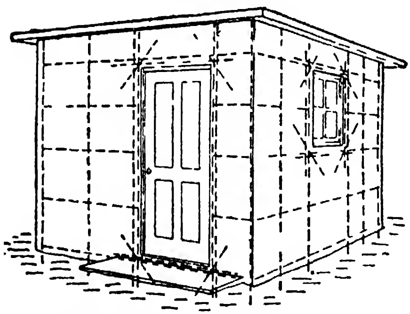


SECTION A-A



Wall reinforced with 3/8" round rods as shown Rods doubled around openings and continous around corners Diagonal rods 2'-6" long at corners of openings

FIGS 5,834 to 5,836—Details of rectangular concrete milk house

NOTE — ***Effect of Cold Weather on Concrete.*** Experience has shown that the effect of heat on concrete is to hasten setting and the effect of cold is to retard setting During cold weather concrete sets very slowly If subjected to freezing weather it will freeze It has been found that concrete which is frozen only once and then allowed to thaw out and properly harden is not injured, but concrete which has alternately frozen and thawed loses its strength and is unsatisfactory It should be carefully protected and not allowed to freeze at all Frozen concrete closely resembles properly hardened concrete and will give a resounding ring when hit with a hammer the same as good concrete The way to distinguish between the two is to pour some hot water on the concrete in question, if it is frozen it will become soft It has been generally proven that concrete which has been protected from freezing for forty eight hours to four or five days, depending upon the degree of cold, can then be subjected to freezing weather without danger of having bad results *The thing to do when handling concrete work in cold weather is to have conditions as near like those of summer as are possible to secure,* that is, do the work inside a room heated to at least 50° F, and allow the concrete to harden in this temperature, or to do the work outside, heat the materials, place the concrete quickly and protect it by covering, so as to retain its heat as long as possible. When weather conditions require it, provide artificial heat during early hardening Concrete itself develops some heat during the setting process

Rectangular Milkhouse

Materials required

Cement	62 sacks
Sand	5⅔ cu. yds.
Pebbles or broken stone	9 cu. yds.
Reinforcing 975 ft. ⅜ in. steel round rods.	

Concrete Mixtures

Foundation	1:3:5
Walls above ground	1:2½:4
Roof, tank and floor	1:2:3

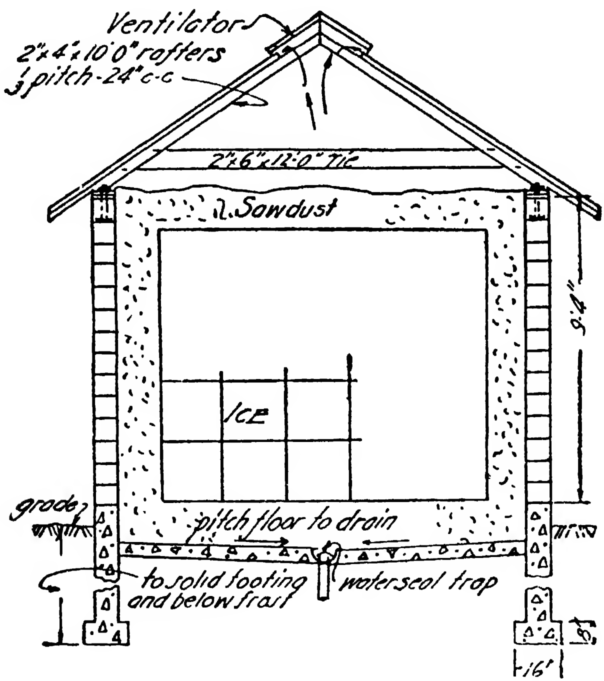
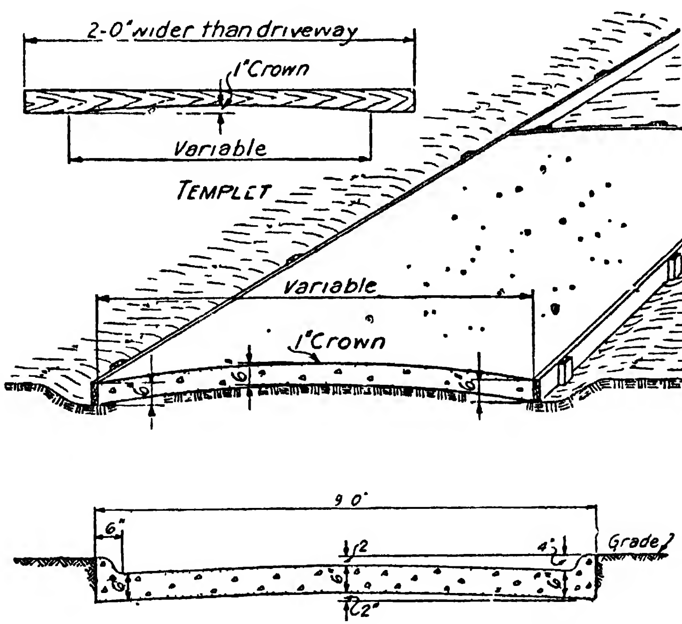


FIG. 5,837.—Concrete block ice house having a capacity of between 20 and 25 tons. A circular monolithic ice house may be built by using ordinary silo forms. Plans can be adapted to build a larger ice house if desired. At least 12 ins. should be allowed on all sides and on top and bottom for sawdust or some other form of packing or insulating material. Between 40 and 50 cu. ft. of space are required for one ton of packed ice. The figures in the following table give the approximate capacity of ice houses of eleven different sizes. These figures have taken into consideration the space occupied by packing material 12 ins. thick, recommended to be used around sides, top and bottom.

Driveway Construction.—An attractive concrete driveway adds much to the appearance of the grounds, and provides a year round passage to the street or highway.

The type of driveway to build depends largely upon its use. Where subjected to hard service, pavements covering the entire drive area will give the best satisfaction. The construction details for driveways of this type are shown in figs. 5,838 and 5,839.

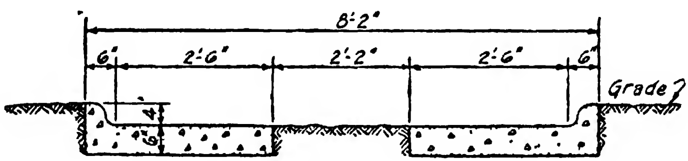
Again where a driveway is subjected to occasional use only, parallel strips of concrete will give satisfactory service. Meth-

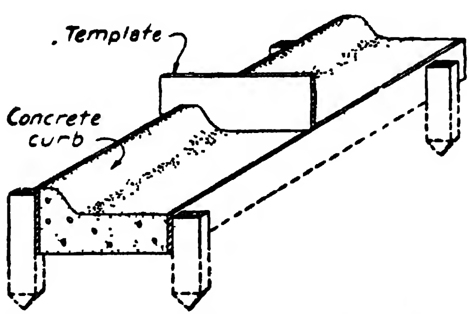


FIGS 5,838 and 5,839 —Method of constructing pavement type of driveway Fig 5,839 illustrates a cross section of straight or curved driveways where radius of inside edge is not less than 25 feet.

ods of construction for a driveway of this latter type is shown in fig. 5,840. It is important, however, that a strip driveway be built with curves on the outer edge to protect the lawn.

The pavement type of driveway is usually made from 8 to 10 feet wide. A 6 inch slab is recommended in order to take care of coal and other delivery trucks. The center of the driveway should be given a crown or valley to insure drainage. The crown or valley is produced by means of a templet which shapes the surface so that the center is higher or lower than the outer edges as shown in fig. 5,838. The base also is shaped so that the finished pavement will have a uniform thickness. The area upon which the pavement is to lay should be well compacted before concreting. Use 2×6 inches or 2×8 inches for side forms and set cross pieces at right angles every 20 or 30 feet to provide expansion and contraction joints. One course construction is recommended using the same mixture of concrete throughout.





FIGS. 5,840 and 5,841 —Construction method for a parallel strip type of driveway and method for setting up of concrete form.

Finishing is done with a wood float a few hours after placing concrete, when it is stiff but still workable. An old canvas or rubber belt, 4 to 6 inches wide and 12 feet long will be found very useful in producing an even surface for flat or crowned pavement. The belt is drawn back and forth across the pavement, working slowly forward as the concrete is brought to desired smoothness.

Outdoor Fireplace Construction.—Fireplaces and barbecue pits are often built of concrete masonry units. Detail construction drawings for such a barbecue pit or stove are shown in figs. 5,842 and 5,843.

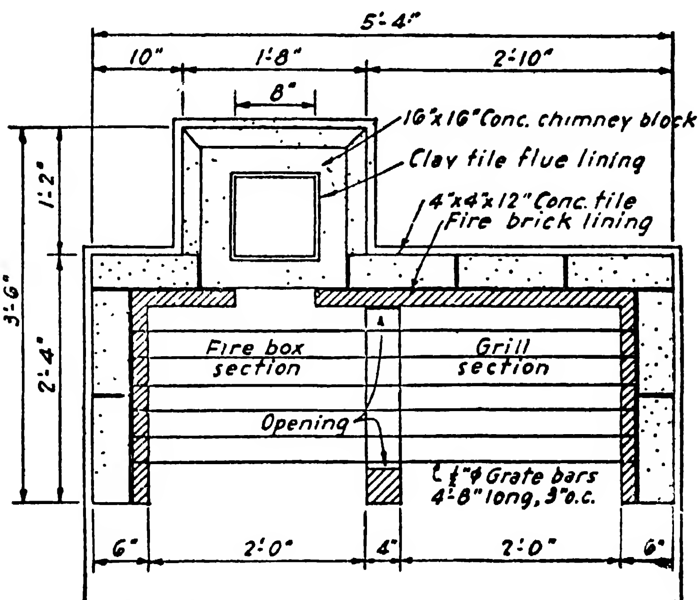


FIG. 5,842.—Showing details of construction for a concrete masonry barbecue pit or stove.

It may be built as a separate unit or as part of the garden wall, depending upon the landscape effects desired. When landscape layout permits a selected spot should be selected. If there be tall trees and heavy shrubbery in the garden area a fireplace with a tall chimney would be appropriate. Whenever possible, however, the fireplace should be so placed that the opening will face the prevailing wind to assure good draft and also to keep the smoke away.

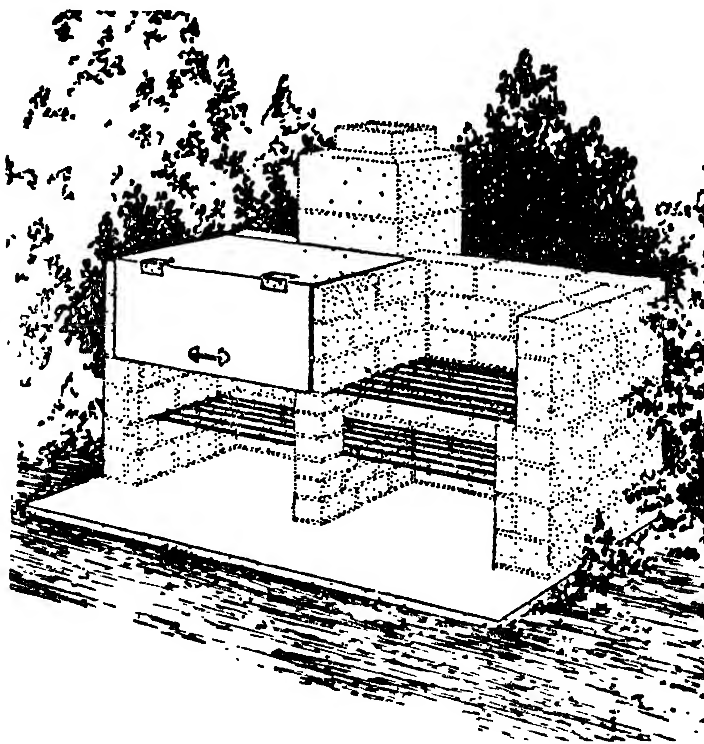


FIG. 5,843.—View of completed concrete masonry barbecue pit or stove.

Concrete masonry units may be 4, 6 or 8 inches thick depending upon the type of fireplace to be erected. Mortar for laying up these units should be carefully mixed, using 1 sack Portland cement, 20 pounds hydrated lime and 4½ cubic feet mortar sand. Mix these materials together dry in a mortar box. Then add water and again mix thoroughly to obtain desired plasticity.

One 3×4 inch steel angle of proper length is required over the fireplace opening.

Cast-In Place Concrete Fireplaces.—Fireplaces similar to those built of concrete masonry may be erected with concrete placed in forms. The mix used here is the same as that for the base of the masonry fireplaces. Well braced forms of proper dimensions should provide for 6-inch thick walls. The reinforcement should comprise ¼ inch steel bars, 12 inches on center in the walls both horizontally and vertically. In place of bars a welded wire fabric having an equivalent cross-sectional steel area will provide sufficient reinforcement.

Fire-Brick Lining.—Most fireplace designs include a fire-brick lining. In small barbecue pits, however, a fire-brick lining is not absolutely necessary. Two properties of good concrete—durability and fire resistance—eliminate any need for fire-brick lining in small fireplaces.

Precautions. —1. In southern climates where little frost enters the ground, deep foundations are not necessary. Farther north, however, where several feet of frost is not unusual, it is best to have a good, solid foundation reaching below the frost line.

2. Do not be too impatient to try out the new fireplace. A fire built too soon after the oven is completed will dry out the concrete and mortar, possibly causing cracks. Cure the concrete properly. Keep it damp for two weeks. This may be done by sprinkling it often so that it remains in a moist condition during this period.

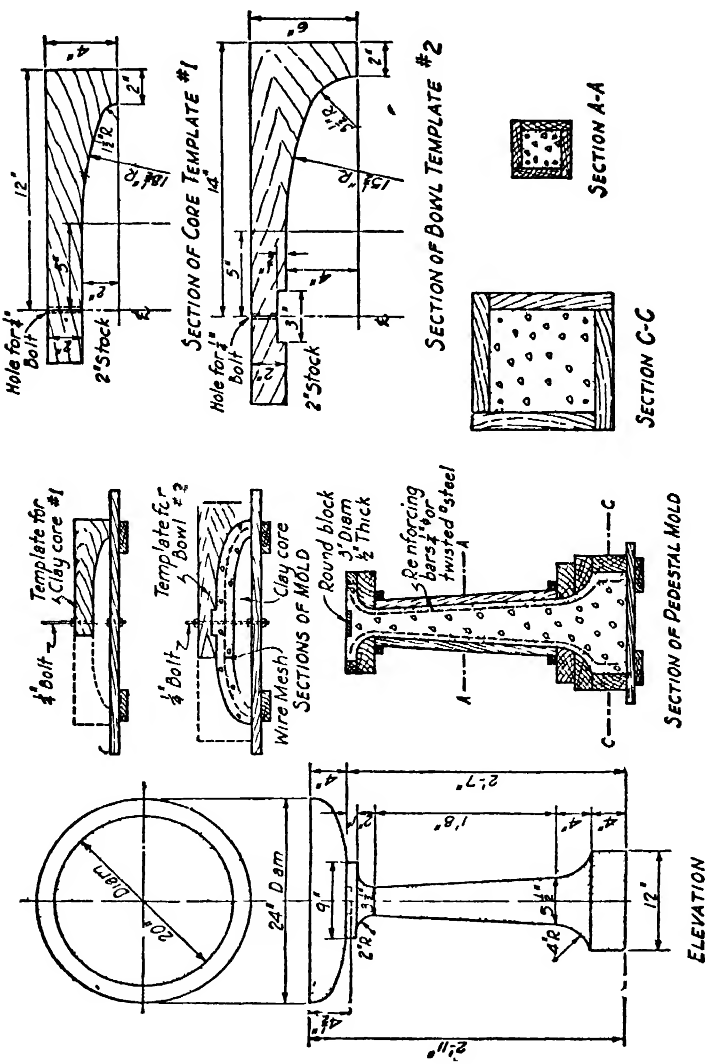
3. Select the oven, steel plates or grills after the fireplace is completed These fixtures can then be cut to correct size, avoiding errors and extra expense.

Concrete Bird Bath and Pedestal Construction.—The construction features for a simple bird bath and pedestal are shown in figs. 5,844 to 5,851. The forms for the pedestal are assembled as shown; shellac to prevent warping and oil their interior surfaces to facilitate removal. Reinforcement for the pedestal consists of four ¼ inch steel rods bent as shown and placed so that they will not be nearer than 1 inch to the surface. In placing the concrete, deposit a small amount in the forms compacting it by tamping with a stick or lath cut like a chisel at one end. Take care in placing the concrete so that the reinforcement will not be moved. After the concrete is placed, a round hardwood plug or dowel is centered in the fresh concrete to provide attachment for the separately-built basin.

A smooth platform about 36 inches square is required in building the bowl. A ¼ inch bolt 8 inches long is fastened in an upright position in the exact center of the platform. This bolt is used as a pivot for the templets which shape the core and the bowl of the bird bath.

The templets may be made of wood as shown or cut from sheets of metal. The curvature may be varied to suit the design. The mold or core, forming the basin is built up of moist clay or a plastic clayey mixture. Templet No. 1 is placed on the bolt and revolved as the clay is built up to produce a smooth, even core. Templet No. 1 is then removed.

After the clay has stiffened, which will require several hours, a 1 inch layer of concrete is placed over the clay and the reinforcing mesh is put in position. The second templet is then placed on the bolt or pivot and as more concrete is placed the templet is revolved and the bottom of the basin formed. The concrete mixture in this case must be so stiff that it will not slide down. Less water or slightly more aggregate than will produce a customary workable mix will accomplish this. Use 4 gallons of water per

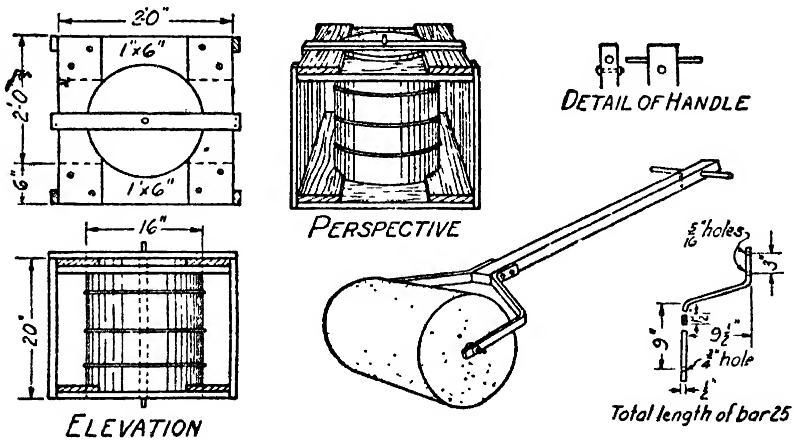


FIGS. 5,844 to 5,851.—Showing detail construction method for concrete bird bath and pedestal.

sack of cement or relatively less if aggregates are moist. The surface may be lightly troweled to obtain the desired smoothness.

Concrete Lawn Roller Construction.—Detail drawings for a medium size lawn roller are shown in figs. 5,852 to 5,857. The forms are assembled as indicated, fitting the clamps around the galvanized iron sheet which is bent to circular form with its ends overlapping. If necessary the metal may be tacked to the clamps. An iron pipe is set in the exact center of the form, using wood strips with accurately bored holes to fit the pipe at top and bottom. Oil all surfaces with which the concrete will come in contact to make removal of forms easy.

Place the concrete in the forms spading it well and smooth off the top with a trowel. Metal form may be taken off after about 48 hours and any holes in the surface filled with 1:2 Portland cement-sand mortar. Allow roller to cure for at least 10 days, wetting thoroughly every day. After it has cured thoroughly, the roller may be assembled as indicated. A handle such as shown can be obtained from the local hardware dealer, or made with pipe and fittings as shown.



FIGS. 5,852 to 5,857.—Construction details for making a concrete lawn roller.

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